THE

AMERICAN NATURALIST

VOL. XXXVI. *February, 1902.* NO. 422.

A NEW AGRICULTURAL ANT FROM TEXAS, WITH REMARKS ON THE KNOWN NORTH-AMERICAN SPECIES.[1]

WILLIAM MORTON WHEELER.

THE genus Pogonomyrmex, comprising the true "agricultural ants," is one of several formicid genera peculiar to the American fauna. It comprises more than a dozen species which range from Montana to Argentina, often over wide areas, though apparently absent from considerable portions of this vast region. As the species are mostly large and conspicuous and inhabit exposed situations, they have attracted more attention than many of our American ants. Notwithstanding this fact, however, we are still very far from possessing an adequate knowledge of the habits and taxonomic relationships of the various members of the genus.

The species described in the following pages seems to have escaped attention hitherto on account of its idiosyncrasies. It is small and inconspicuous, of a timid disposition, and lives under stones, instead of in exposed grassy regions like the other North-American species. It is, moreover, rather rare

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 24.

and local. Up to the present time I have seen it in only one locality, on the flat limestone terraces which form the southern slope of Mt. Barker, a short distance from the Colorado River, near Austin, Texas. Though but a few acres in extent and on warm days fully exposed to the rays of a pitiless sun, these terraces are, nevertheless, a rich collecting ground for the myrmecologist. All about the place there is something of the local color of the dry Mexican plateau, and this peculiarity extends also to the ant-life of the region. Here, under the flat, detached pieces of limestone scattered among a sparse but interesting vegetation,[1] occur at least four species of grain-storing ants: the new Pogonomyrmex described below, a golden yellow variety of the ubiquitous subtropical and tropical "fire ant" (*Solenopsis geminata* Fab.), and two species of Pheidole (a diminutive new form and *Ph. kingii* André, var. *instabilis* Emery). This is also one of the few localities in which I have seen the little mushroom-growing ant *Cyphomyrmex wheeleri* Forel, the first of its genus to be taken in the United States.[2] Here, too, occur *Odontomachus clarus* Roger, *Pheidole hyatti* Emery, *Xiphomyrmex spinosus* Pergande, and, of course, *Dorymyrmex pyramicus* Rog., *Forelius fœtidus* Buckley, and *Camponotus fumidus* Rog., var. *festinatus* Buckley. While many of these species abound in this locality, I have failed to find more than a dozen nests of the new Pogonomyrmex, and these were so close together — within an area of

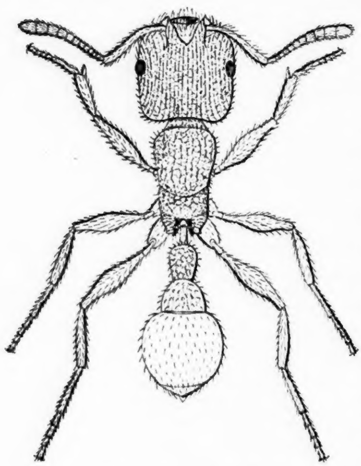

FIG. 1. — *Pogonomyrmex imberbiculus* n. sp. Worker. Dorsal view.

[1] A brief account of the flora of this region is given by Oberwetter ('86).

[2] I have since discovered a dark variety of *C. rimosus* Spinola at New Braunfels, Texas.

a few square rods — as to suggest that they may have been merely parts of a single colony. These nests were all under rather small flat stones, which were often located by following up the foraging workers as they trudged home slowly over the hot soil in the intense glare of the sun. The nest is a simple structure consisting of a few broad and very shallow surface chambers (1½–3 inches in diameter) connected by one or two vertical or oblique galleries with a few chambers situated at lower levels in the soil. The superficial chambers always contained from about ½ to ⅔ of a teaspoonful of seeds, mostly, but not exclusively, from the grasses of the neighborhood. These seeds were all dry and unhusked, and hence of a very different appearance from those found in neighboring nests of *Solenopsis geminata*. This ant carefully shells its seeds and treats them in some singular manner, so that they all have a glistening yellow color like the ants themselves. Although I collected the Pogonomyrmex at different times of the year and excavated their entire nests, it was impossible to discover either the queens or the males. Even the larvæ and pupæ, found in great numbers in the chambers of the nests June 1–10 were all of the worker type. The specific description which follows is drawn therefore exclusively from the worker. This, however, can scarcely be confounded with the workers of any of the other North-American species of the genus.

Pogonomyrmex imberbiculus n. sp.

Worker: Length 4–4.8 mm. Color rich ferruginous red, legs somewhat paler, eyes and edges of mandibles black; hairs covering the body yellowish. Head quadrangular, scarcely longer than broad, its posterior margin hardly incised. Mandibles sexdentate, the two apical teeth largest, blades traversed nearly their entire length by coarse longitudinal ridges. Clypeus subopaque, with longitudinal rugæ separated by series of faint striæ and provided with long, anteriorly projecting hairs. Antennal scape covered with faint longitudinal ridges, the hairs on its anterior surface suberect, on the posterior surface more appressed. Dorsal and lateral surfaces of head covered with coarse rugæ, which are scarcely divergent behind and connected with one another by irregular transverse ridges; the areolæ thus enclosed are subglabrous, coarsely and confluently punctate. Hairs on the upper and lateral surfaces of the head short, erect, subobtuse. Lower surface of head more delicately longitudinally rugose, with somewhat longer

and more tapering hairs, which, however, do not form a conspicuous beard as in the other North-American species of Pogonomyrmex. Thoracic dorsum and pleuræ covered with coarse reticulate rugæ, enclosing more finely reticulate rugose and confluently punctate, polygonal areolæ. In some specimens the rugæ have a transverse trend on the pronotum and a slightly longitudinal trend on the meso- and metanotum; promesonotal suture usually indistinct. Epinotum armed with two pairs of rather blunt spines, scarcely longer than the breadth of their bases; anterior pair connected with each other at the base by a transverse ridge and with the spines of the posterior pair on either side by a longitudinal ridge; the space thus enclosed is subglabrous and traversed by a few longitudinal rugæ. Hairs covering the thorax short, subobtuse, and perfectly erect. Stem of petiole laterally compressed, slender, provided below near its insertion with a small but distinct tooth; node scarcely longer than the stem, its apex obtuse in profile, its dorsal surface subelliptical, covered with coarse reticulate rugæ like those of the thorax, but bearing somewhat longer and more pointed hairs. Postpetiole campanulate, subdepressed dorsally, with a prominent rounded projection below near its base; sculpture decidedly fainter than that of the petiole and consisting of rather indistinct rugæ interspersed with punctate spaces. Gaster small, smooth, and shining throughout, without basal striæ and punctures, and covered with prominent, suberect hairs. Legs glabrous, clothed with suberect hairs.

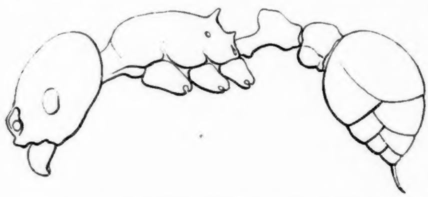

FIG. 2. — *Pogonomyrmex imberbiculus* n. sp. Worker. Profile view.

While *P. imberbiculus* is very sharply distinguished from any of the other North-American species of Pogonomyrmex by its small size, peculiar sculpture, and the lack of the beard of long hairs which suggested the generic name to Mayr ('68, p. 11), it is, singularly enough, very closely related both in these and other particulars to a Brazilian species, *P. nægelii* Forel ('86 pp. 4, 5). Through the kindness of Professors Forel and Emery, who have sent me specimens of the Brazilian form, I have been able to compare the two species, which at first sight would almost certainly be confounded. More careful examination, however, reveals the following differences: In *nægelii* the gaster is of a distinctly darker color than the head and thorax, and its extreme basal portion is longitudinally striated and finely

punctate. The head, thorax, and petiole are somewhat more coarsely rugose than in *imberbiculus*, and the epinotal spines more acuminate at their tips. The most striking difference, however, is in the sculpture of the postpetiole, which in *nægelii* is but little finer than that of the petiole, whereas in the Texan species this segment is nearly smooth.

Recently Forel ('**99**, pp. 61, 62) has discovered in Columbia still another beardless and otherwise aberrant Pogonomyrmex (*P. mayri*), which he assigns to a new subgenus, Janetia. This is based very largely on the predaceous, non-granivorous habits of the species and on the neuration of the male fore wings, which exhibit only a single cubital cell. He expresses doubt as to whether *P. nægelii* should be included in his new subgenus, but leaves the matter undecided, as he supposes the male of this species to be unknown. This, however, appears to be an oversight, since Mayr ('**87**, p. 612) describes both the male and female of *P. nægelii*. He clearly states that the female has two cubital cells and that the wings of the male are the same as those of the female. Now from the very close affinity of *P. imberbiculus* with *P. nægelii* it is safe to predict that the latter is also a grain-eating species. We are compelled, therefore, to regard the small group of Pogonomyrmex comprising the beardless Texan and Brazilian species as transitional between Pogonomyrmex *sensu stricto* and the subgenus Janetia rather than as belonging to the latter. It may be advisable ultimately to erect a special subgenus for the two small grain-storing species, but a careful study of the males and females of all the known species of the genus should be previously undertaken.

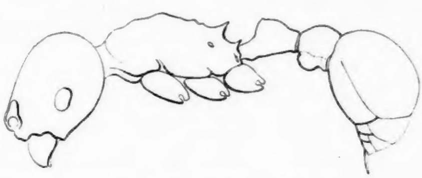

FIG. 3. — *Pogonomyrmex nægelii* Forel. Worker.

The workers from two nests of *P. imberbiculus*, with their numerous pupæ, nearly mature larvæ, and their store of seeds, were put together in the same artificial nest. The ants from different nests fraternized without the slightest signs of hostility,

thereby indicating that they were perhaps members of the same colony. They soon distributed their progeny and provisions in three separate piles — one for the larvæ, one for the pupæ, and one for the seeds. During the first few days of their captivity the ants were fed on house flies. These were not only eaten with avidity by the adult Pogonomyrmex, but cut into pieces and fed to the larvæ in the same manner as I have described for the Ponerinæ and some Myrmicinæ ('00 and '00a). On one occasion nearly every larva in the nest could be seen munching a small piece of house fly. But a still more remarkable method of feeding was adopted after a few days, when the supply of insect food was exhausted. Then the ants were seen to bring seeds from their granary, crack them open with their strong mandibles, and, after consuming some of the softer portions themselves, to distribute the remainder among their larvæ. The latter could be seen under the lens cutting away with their mandibles and devouring the softer starchy portions of the seeds. The hard and useless hulls were afterwards carried away by the ants and placed on the refuse heap. These observations show that *the larvæ of certain ants are not only able to subsist on solid food, but even on food of a vegetable nature.* The adaptation of what were probably once exclusively carnivorous ants to a vegetable diet, although not yet complete, is, nevertheless, so far advanced that the larva already participates in the peculiar feeding habits of the adult insect. The *P. imberbiculus* seem not to possess the power of feeding one another or their larvæ by regurgitation. At any rate they were not seen to make use of this method in the artificial nests.

These observations are quite in line with some which I made on artificial nests of the large "agricultural ant of Texas" (*P. barbatus* Smith, var. *molifaciens* Buckley). In this case the workers carried the seeds, a few at a time, into the chamber containing the queen and her attendants. Here the ants, including the queen, gnawed away the soft portions of the seeds till they had satisfied their hunger. Thereupon the empty hulls were carried out. Even when the nest was supplied with honey or syrup, each ant helped herself from the food supply, and neither fed other ants nor permitted herself

to be fed by regurgitation. I deem it probable, therefore, that the larvæ of *molifaciens* are also fed like those of *imberbiculus* by what we may call the direct method, to distinguish it from the indirect method adopted by the Camponotinæ. In the Ponerinæ and many Myrmicinæ, including Pogonomyrmex, the direct appears to be the prevailing, if not the exclusive, method. In the Camponotinæ, on the other hand, the indirect method prevails, since at a given time only a comparatively small number of ants function as caterers for the whole colony and distribute the food by regurgitation to the larvæ and the other ants.

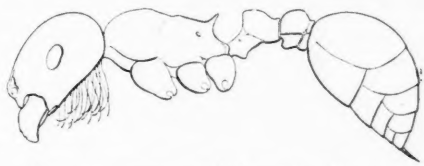

FIG. 4. — *Pogonomyrmex barbatus* F. Smith (typical). Worker.

It may not be altogether out of place in this paper to record a few other observations on *P. molifaciens,* inasmuch as this form has been singled out among all the known members of the genus as presenting certain remarkable instincts. Lincecum is responsible for the myth that this Pogonomyrmex sows a certain species of grass, the "ant rice" (*Aristida oligantha*), protects it from harm and frees it from weeds while it is growing, for the purpose of reaping the grain. This notion, which even the Texan schoolboy has come to regard as a joke, has been widely cited, largely because the great Darwin stood sponsor for its publication in the *Journal of the Linnean Society* (**'62**). McCook, after spending a few weeks in Texas observing *P. molifaciens* and recording his observations in a book of 310 pages (**'79**), failed to obtain any evidence either for or against the Lincecum myth. He merely succeeded in extending its vogue by admitting its plausibility.[1]

[1] Not only have able myrmecologists like Forel (**'99**, p. 63) been deceived by the accounts of Lincecum and McCook into assuming the existence of a kind of symbiotic relation between the Pogonomyrmex and the "ant rice," but this myth, now in its fortieth year, still flourishes in the newspapers. There it grows by intussusception with other droll fancies, as shown in the following extract from the *Chicago Tribune* of May 19, 1901: "Many species of ants fertilize and apparently cultivate many varieties of foodstuffs. The trimmer ants and the

Two years of nearly continuous observation of *P. molifaciens* and its nests enable me to suggest the probable source of Lincecum's and McCook's misconceptions. In either case the observer has started with a few facts and has then stopped short to draw inferences before gathering more facts. If the nests of *molifaciens* be studied during the cool winter months, — and this is the only time to study the nests leisurely and comfortably, since the cold subdues the fiery stings of their inhabitants, — the seeds which the ants have garnered in many of their chambers will often be found to have sprouted.[1] On sunny days the ants may often be seen removing these seeds when they have sprouted too far to be fit for food and carrying them to the refuse heap, which is always at the periphery of the cleared earthen disk or mound. In this place the seeds thus cast away as inedible often take root and somewhat later form an arc of tall grass more or less closely approximating a complete circle around the nest. Since the Pogonomyrmex feeds largely, though by no means exclusively, on grass seeds, and since, moreover, the seeds of the Aristida are a very common and favorite article of food, it is easy to see how this grass should often predominate in the circle. In reality, however,

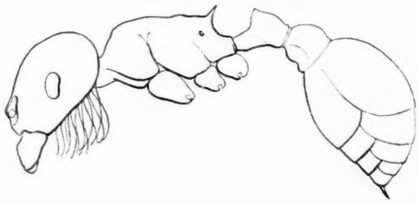

FIG. 5.—*Pogonomyrmex occidentalis* E. T. Cresson. Worker.

harvesting ants of Texas are both of this kind. The trimmers prune a sort of weed which is to their taste so that it shall grow strong and sturdy, and the harvesting ants go even further than this. They clear disks several yards across around about their nests of all manner of vegetation. Then they plant these farms with ant rice, which they watch and tend until it ripens, keeping the crop carefully free of weeds and insects. The ants' dogs keep the ant cows out of the growing grain, and the farmer ants probably sit around themselves at night with shotguns to shoot colored ants suspected of pilfering."

[1] The same is true of the seed stores of *Pheidole kingii*, var. *instabilis*. It is therefore certain that these ants are not able to prevent the seeds from germinating as Moggridge (**'73**, p. 54) claims for the European species of Messor, except by conveying them to drier chambers. And in protracted spells of wet weather even this precaution seems to be of no avail.

only a small percentage of the Pogonomyrmex nests, and only those situated in certain localities, present such circles. Now to state that the *molifaciens*, like a provident farmer, sows this cereal and guards and weeds it for the sake of garnering its grain is as absurd as to say that the family cook is planting and maintaining an orchard when some of the peach stones which she has carelessly thrown into the back yard with the other kitchen refuse chance to grow into peach trees.[1]

There are several other facts which show that the special ring of grass about the *molifaciens* nest is an unintentional and inconstant by-product of the activities of the ant colony. First, the Aristida often grows in flourishing patches far from the nests of *molifaciens*. Second, one often finds very flourishing ant colonies that have existed for years in the midst of much-traveled roads or in stone sidewalks often a hundred or more feet from any vegetation whatsoever. In these cases the ants simply resort for their supply of seeds to the nearest field or lawn, or pilfer the oat bin of the nearest stable. Third, it is very evident that even a complete circle of grass like those described by Lincecum and McCook would be entirely inadequate to supply more than a very small fraction of the grain necessary for the support of a flourishing colony of these ants. Hence, they are always obliged to make long trips into the surrounding vegetation, and thereby wear out regular paths which radiate in different directions, often to a distance of forty to sixty feet from the entrance of the nest. These paths in the case of the Mexican agricultural ant (*P. barbatus* sens. str.) remind one of human footpaths, as they may be as much as four to six inches wide in places. The existence of these paths, which are often found in connection with grass-encircled nests, is alone sufficient to disprove Lincecum's statements.

McCook's conceptions of the external architecture of the *molifaciens* nest are hopelessly confused, notwithstanding the

[1] Lincecum was fond of attributing agricultural and horticultural propensities to ants. Thus he states (**'67**, pp. 28, 29) that the leaf-cutting ant (*Atta fervens*) plants trees and vines on its nest! At the same time of course, like McCook, he failed to observe the marvelous mushroom-gardening habits of these ants, — another instance in which truth is stranger than fiction.

fact that he seems to have been much interested in ant architecture, and has devoted no less than thirty-five pages to a presentation of this feature. It does not seem to have occurred to him that the character of the architecture of *molifaciens* must be profoundly affected by two factors, — the nature of the soil and the age of the ant colony Gravel-cone nests can, of course, be built only in soil that abounds in small pebbles, whereas nests dug in a uniform soft, loamy soil, like that of northern Texas along the Red River, must be simple disks or very low mound nests, as the soil brought up by the ants is spread out by the rains and the movements of the ants themselves. On the other hand, a small, incipient colony of ants is unable to clear away much of the vegetation about the entrance to the nest. At least the tougher plants, like the grasses, whose hard siliceous stems offer considerable resistance to the mandibles of the ants, cannot be cut away till the colony waxes strong both in the size and number of its individuals. Then the work proceeds rapidly, the circular area coëxtensive with the subterranean galleries is completely cleared and opened up to the sun's light and warmth. This clearing is evidently an adaptation for insuring the greatest possible dryness in the granaries of the nest. The circular denuded disk or mound enlarges slowly year after year, and it should be noted that during this progressive enlargement even the peripheral circle of ant rice is quite as ruthlessly cut down and cleared away along its inner edge as any other plants that may cast a shadow on the disk, and thereby enable the soil to retain the moisture.

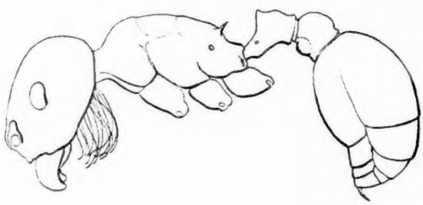

FIG. 6. — *Pogonomyrmex subdentatus* Mayr. Worker.

While we possess the observations of Buckley (**'61**), Lincecum (**'62**, **'66**, **'74**), and McCook (**'79**), on the habits of the Texan *P. molifaciens*, of Mrs. Mary Treat (**'77**) and McCook (**'79**) on the "Florida harvester" (*P. badius* Latr.), and of McCook (**'82**)

on the "occident ant" (*P. occidentalis* Cresson), no observations seem to have been published on the two distinctively Californian species (*P. californicus* Buckley and *P. subdentatus* Mayr). My friend Dr. Harold Heath, who has made strenuous effort to fill this gap in our knowledge, kindly supplies me with the following notes on the latter species:

The red agricultural ant (*P. subdentatus*) is one of the most abundant ants in the neighborhood of Pacific Grove, Cal. Here one is constantly coming upon them and their nests along the roadsides and in the sandy soil of the woods and fields. The nests, so far as I have been able to observe, are never placed under stones or logs, but in exposed regions, — that is, away from the shadow of vegetation. Little attempt is made to clear away the short grass in their vicinity. The earth carried out from their burrows is usually deposited several inches from the opening, especially along their runways, which extend out in various directions into the surrounding region. Large quantities of chaff and the hulls of seeds are also scattered about, usually in fairly definite dumping grounds, but neither these materials nor the earth are ever fashioned into a mound. Some of the ants entering the nest carry pods, others bits of leaves and grass, all well dried, while an equal number of the insects leaving the nest carry away similar materials, but the pods are emptied of their seeds and the leaves are evidently thrown away as non-nutritious and useless. Within the nest there are several little granaries, or accumulations of seeds, each sometimes amounting to as much as a teaspoonful, though usually considerably less. The foodstuffs seem to be carried to one spot within the nest and there hulled and assorted. The seeds are then carried to the storehouses, while the chaff is at once carried out, although it may accumulate and almost completely fill a burrow for a distance of several inches. On comparing the seeds taken from the nest with those of the surrounding plants, I find them to be chiefly those of a species of grass and of two species of Compositæ. At the present writing these seeds are fully ripe, but as soon as those of other plants mature they appear to be equally acceptable. I may add that these ants defend their homes with extraordinary pugnacity and inflict stings more painful than those of the honey-bee. As I write I feel the dull ache of several stings inflicted more than a day ago.

These observations, by a thoroughly competent zoölogist, show that at least one of the Californian species of Pogonomyrmex conforms rather closely to what is known of the other species of the genus.

Some interesting problems center about the geographical distribution of the species of Pogonomyrmex. These ants

evidently represent an extreme adaptation to the open, dry and sunny, and more or less grass-covered regions of the New World. Such regions are, perhaps, most typically represented by the deserts of Wyoming, the plateau of central and northern Mexico, and the pampas of La Plata. The area occupied by the genus and extending, as above stated, from Montana to Argentina, presents in North America an eastern offshoot to Florida (*P. badius*) and a peculiar western offshoot to the Sandwich Islands (*P. occidentalis*). In South America there is between Colombia and Argentina a considerable area from which species of Pogonomyrmex are unknown, but the continuity of the distribution, though broken at this point, is at least in part preserved further to the east by the Brazilian *P. nægelii.*

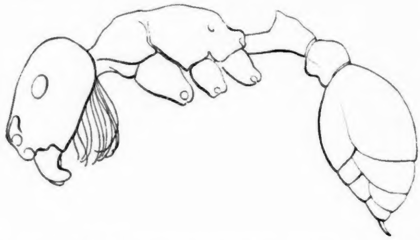

FIG. 7. — *Pogonomyrmex californicus* Buckley. Worker.

This distribution over two continents naturally suggests an inquiry as to whether the species arose in North America and migrated thence along the Andes into South America, or had their origin in the pampas of Argentina and migrated into North America over the same lofty road. Two authors, v. Ihering (**'94**, p. 416) and Emery (**'94**, p. 354), who have seriously studied the interesting problems suggested by the distribution of the American ants, agree in regarding North America as the primeval home of the species of Pogonomyrmex. Concerning this genus and the genera Dorymyrmex and Forelius, which have a very similar distribution, Emery says:

Their migration probably proceeded along the Andes at a time when the climate was cooler and the vegetation therefore different from the present. Later, on the supervention of new floral conditions, they were crowded out of a portion of their former domain by the tropical ant fauna. For the reason that the southern species of Pogonomyrmex and Dorymyrmex are more numerous than the northern, we might, perhaps, assume that these animals had migrated from the south to the north. But it is not in

the least improbable that these ants, like the South-American species of Didelphys, deer, camelids, and mastodons, are of North-American origin. Without being able to adduce stringent proof in favor of my opinion, I nevertheless incline to accept this latter view.

The migration between the continents is supposed to have taken place during the Pliocene. This view of the North-American origin of Pogonomyrmex is supported to some extent by the flourishing condition of the closely allied holarctic genera Myrmica and Stenamma (including the subgenera Aphænogaster and Messor) in the United States and Canada.

A problem of more subordinate interest is suggested by the close morphological relationship of the Brazilian *P. nægelii* and the Texan *P. imberbiculus*, without known forms of a similar aberrant character in the intervening geographical region. It is possible, however, that a more searching investigation of the Mexican and West-Indian fauna may bring to light still other beardless forms of Pogonomyrmex and thereby fill this gap. It should be mentioned, nevertheless, that the new Texan species has all the appearance of being a geological "relict."

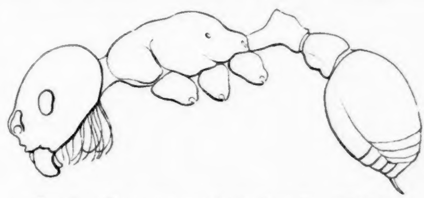

FIG. 8. — *Pogonomyrmex badius* Latreille. Worker.

In conclusion I subjoin a dichotomic table to aid in the identification of the workers of the North-American species of Pogonomyrmex:

1. Small species, less than 5 mm. long; under surface of head without a beard of long curved hairs; epinotum armed with four spines; head, thorax, and petiole coarsely reticulate rugose, base of gaster not striated. Formicary under stones. (Central Texas.)
P. imberbiculus n. sp.

2. Larger species, more than 5 mm. long; under surface of head with a beard of long, curved hairs; epinotum with only two spines or none; head and thorax finely rugose, the rugæ being more or less parallel with one another, not reticulate. Formicary not under stones, exposed 3

3. Epinotum with a single pair of spines 5

4. Epinotum unarmed 12
5. Head finely and densely rugose, rugæ but little divergent posteriorly, without or with very indistinct interrugal sculpture . . . . 7 *a–e*
6. Head less densely rugose, rugæ very distinctly divergent posteriorly, interrugal sculpture distinct, consisting of dense foveolate punctures 8
7 *a*. Head, thorax, and legs black; petiole, postpetiole, and gaster red. (Mexico.) . . . . *P. barbatus* F. Smith (**'58**, p. 130)
7 *b*. Cephalic rugæ finer and denser, body ferruginous red throughout. (Mex., Tex., Ind. Ter., Ark., Kans.)
P. barbatus, var. *molifaciens* Buckley (**'61**, p. 445)
7 *c*. Head and thorax brownish red, gaster in part or entirely brown. Rugosity as in 7 *b* or somewhat stronger. (Tex., Col.)
P. barbatus, var. *fuscatus* Emery (**'94**, p. 309)
7 *d*. Rugosity a little coarser than in 7 *a*; head, thorax, and legs black, petiole and postpetiole brown, abdomen red, node of petiole longitudinally rugose. (Marfa, Tex.) . *P. barbatus*, var. *marfensis* n. var.
7 *e*. Head and thorax much more coarsely rugose than in 7 *a–d*. Rugæ irregular in direction on the pro- and mesonotum, on the other regions transverse. Petiole rather strongly and irregularly rugose; its anterior stem-like portion shorter than in *P. barbatus;* postpetiole rugose-punctate. (Cal.) . *P. barbatus*, subsp. *rugosus* Emery (**'94**, p. 309)
8. Head less densely rugose, the rugæ distinctly divergent posteriorly, interrugal spaces densely foveolate punctate 9
9. Lower surface of petiole without a distinct tooth; infraspinal concavity of epinotum rugose, scarcely shining . . . . 10 *a–b*
10 *a*. Head opaque, interrugal punctures distinct. (Col., New Mex., Utah, Ariz., Nev., Wyo., Mont., Kans., Neb., Honolulu.)
P. occidentalis Cresson (**'65**, pp. 426, 427)
10 *b*. Head more shining, interrugal punctures more indistinct; petiole less opaque than in 10 *a*. (S. Cal.)
P. occidentalis, var. *subnitidus* Emery (**'94**, p. 310)
11. Petiole with a distinct tooth below; infraspinal concavity of epinotum shining, without rugæ. (Cal.) . *P. subdentatus* Mayr. (**'70**, p. 971)
12. Interrugal spaces of head rather indistinctly and confluently punctate. Workers monomorphic . . . . 13 *a–c*
13 *a*. Color yellowish red, stem of petiole about the same length as its nodal portion; postpetiole as high as long. (Cal., Lower Cal.)
P. californicus Buckley (**'66**, p. 236)
13 *b*. Darker red than 13 *a*; apical third or more of gaster more or less black; petiole and postpetiole often brown, the former slender, its node longer and less erect, with rounder or but slightly pointed apex. (Lower Cal.)
P. californicus, var. *estebanius* Pergande (**'93**, p. 33)
13 *c*. Yellowish red, gaster brown except at the base; stem of petiole shorter than the very long nodal portion, which is pointed above;

postpetiole not as high as long. Sculpture fainter than in 13 *a*; petiole and postpetiole punctate, without rugæ. (Cal.)

P. californicus, subsp. *longinodis* Emery (**'94**, p. 311)

14. Interrugal spaces regularly foveolate punctate. Color ferruginous red. Workers polymorphic, *i.e.*, with size of head greatly varying. (N. C., Ga., Fla.) . . . . . *P. badius* Latreille (**'02**, p. 238)

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COLEBROOK, CONN., September 9, 1901.

PHYLLOSPADIX AS A BEACH-BUILDER.[1]

RALPH ERWIN GIBBS.

In December, 1898, while overhauling a heap of seaweeds recently collected by Prof. W. A. Setchell and myself at Bodega Bay, California, I discovered, clinging to a branch of Amphiroa, a small brown object which bore, at first sight, a rude resemblance to a beetle's head with rigid, bristle-fringed antennæ. On examination, however, it was evident that this nondescript, clasping the Amphiroa in such a way that the reflexed bristles, or "barbs," of its arms resisted attempts to detach it, was the seed or fruit of some flowering plant. Further, it was obvious that this contrivance of arms and bristles was a unique and most interesting example of dissemination mechanism.

As there are extensive beds of eelgrass (Phyllospadix) growing in shallow water along the rocky shores of Bodega Bay, the possibility suggested itself that this was the ripe fruit of Phyllospadix, and upon comparison with the figures of Ruprecht and others it seemed that such was the case,—although our find was, in some respects, very different from what Ruprecht supposed to be the "ripe fruit."[2]

A few weeks later, at Monterey Bay, the matter was put beyond doubt, and given new complexity and interest, when we collected not only an abundance of the fruits, but also young plants in several stages of development. Following up these discoveries, and with the help of Professor Setchell and Dr. W. L. Jepson, I made an investigation, the results of which are here set forth. These results, to anticipate a summary, are, first, some data as to the life history of Phyllospadix, and, second, some speculation as to the significance of the plant from a geological point of view.

[1] Thesis for the degree of M.S., University of California, May, 1900.

[2] Ruprecht, F. J. Neue . . . Pflanzen aus dem . . . Stillen Oceans. 1852.

First we consider the fruit itself. Upon comparison of Figs. 2 and 3 it is seen that our wave-beaten specimen from Bodega, with its long stiff arms, lined with brushes of inflexed bristles, is a decided departure from Fig. 2, which represents the most mature fruit I have been able to find still attached to the spadix. Fig. 2 is also an approximate reproduction of Ruprecht's figure. Fig. 1 shows a younger stage.

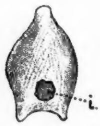

FIG. 1.

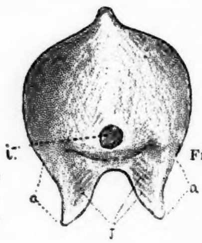

FIG. 2.

FIG. 1.—Early stage of fruit.
FIG. 2.—Later stage of same.

The feature which catches the attention in Fig. 3 is, of course, the arrangements of the two arms, with the bristles or barbs. This is what I have called the "dissemination mechanism"; but that is rather a misnomer, for it is a device, not for scattering the seeds, but for anchoring them after they have been drifted away from the parent plant.

But the first question is, What is the origin of these barbs, and how are they developed from the object we see in Fig. 2? Curiously enough, the key to this puzzle was unwittingly stumbled upon by Ruprecht in 1852. He noticed upon the fin-like expansion which extends between the body and the arms of the green fruit the parallel darker streaks marked *f* in Fig. 2; for he remarks that, upon dissection, he found imbedded in the softer, semitranslucent tissue, bundles of *braune Fasern*, and it is these brown fibers which, as we shall see, play an important part in one chapter of Phyllospadix life history.

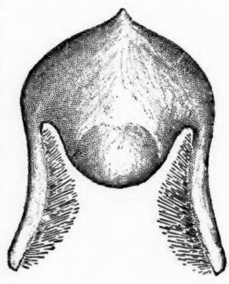

FIG. 3.—Fruit as found attached to Amphiroa.

In Fig. 4 is shown a diagrammatic section of the stage of fruit shown in Fig. 2, cut in the plane of the two arms. The pericarp is here so differentiated that we may distinguish, for convenience, two parts,—what we may call the exocarp, the soft, spongy outer portion; and the endocarp. The latter is thin or absent at the lower end of the seed, but it clasps

the body of it as in a sling of tough, compact tissue, composed of elongated lignified cells. Further, this endocarp, prolonged downward, forms the axes of the arms; and, finally, it produces a great number of very long and thick-walled cells, which lie loosely imbedded in the softer substance of the "fin" (*f*). These "fibers" may be easily separated from one another, and from the enclosing exocarp, except at their lower ends, where they are conjoined with the endocarp of the arms. These slender lignified cells are the *Fasern* of Ruprecht, and now it is to be inquired how they are metamorphosed into the barbs of Fig. 3.

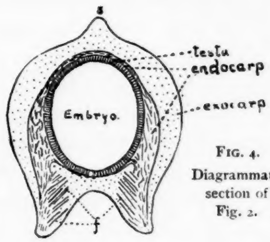

FIG. 4. Diagrammatic section of Fig. 2.

When the ripe fruit is ready to break loose from the spadix, its arms have grown longer and stiffer, as in Fig. 3, but are still, of course, enclosed in the exocarp. Now the fruit begins to drift about, — flung against the rocks, washed up on the beach, and sucked back again, bruised and scoured, in the swirling sand and pebbles of the undertow; and after a little of this rough-and-tumble existence the spongy exocarp begins to wear away, leaving exposed, in the arms and about the upper part of the seed, the hard endocarp, while about the base (*i.e.*, the lower middle part of Fig. 3) there is laid bare the smooth surface of the shell-like testa. But the important point is that the exocarp in which the barbs are imbedded is also got rid of. It easily flakes off and is washed away, and then, with a little more sand-scouring, the freed barbs, springing apart a little, stand out clean, like so many whalebones.

Now our "anchoring mechanism" is uncovered and ready for use. By this time, too, the seed may be ready to germinate, and, for the safe putting forth of leaves, a fixed abiding place is necessary. The seed must be anchored, and, the anchors being ready, the next requisite is a suitable anchoring ground.

Along our coast there are various species of coralline seaweeds (Corallina, Amphiroa) which abound wherever there are rocks between tide-lines. These algæ have slender,

lime-impregnated stems, made flexible by being broken into short joints, and constricted between the joints like a string of coral beads; and they form an intricate, often turf-like, growth over the wave-washed rock.

We could not imagine a better opportunity for Phyllospadix in search of a lodging place; and it seems that Phyllospadix is, in fact, not slow to catch on, for experience showed that the more profitable way to collect Phyllospadix seed was to search at low tide, not in the eelgrass itself, but rather among the corallines covering some flat rock just inshore from the eelgrass beds.

When the fruit, hurried landward by a wave, blunders against a tip of Amphiroa, there is a fair chance that the stem will slip into the crotch of one of the arms. When once this has happened the wanderings of Phyllospadix are over. The many barbs unite to hold whatever is caught, and further knocking about by the waves only serves to wedge the alga more tightly into the grasp of the seed. The segmented structure of the Amphiroa prevents it from slipping through the grip of the arm, and so the seed is safely planted, as it were, in a tree-top. Frequently it even catches two branches of its host, one in either armpit, and so swings secure on two anchors.

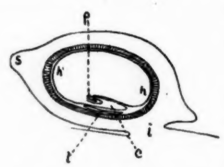

FIG. 5. — Diagram of dorsiventral median section of Fig. 2. *c*, cotyledon; *i*, insertion of pistil; *h*, *h'*, hypocotyl; *l*, folded edge of hypocotyl.

Time and seed are now ripe for germination. What next takes place will be better understood upon referring to Fig. 5. Here is a longitudinal, dorsiventral, median section of the immature fruit. The cavity of the seed is filled by the embryo, of which the bulk consists in the hypocotyl (*h*, *h'*). The cotyledon (*c*) is short, straight, and tubular, and serves merely as a sheath for the plumule (*p*). It lies upon the ventral side — as regards the pistil — of the hypocotyl, and points toward the base, *i.e.*, in the direction of the arms. The testa (*t*) is formed of a single layer of cells with thick, lignified cell walls, and thus, while it serves, like an arch of bricks, to protect the embryo from outside pressure, it is readily burst open by the swelling within of the hypocotyl.

Perhaps the exposure, and consequent partial drying of the seed, at low tide helps to crack the testa. At any rate, when germination begins the basal end (*h*) of the hypocotyl bursts through the testa and presses the broken edge of it back, leaving a clear passage for the cotyledon. The hypocotyl grows no farther than this, and eventually, when its store of substance has served to give the young plant a start, it dies away.

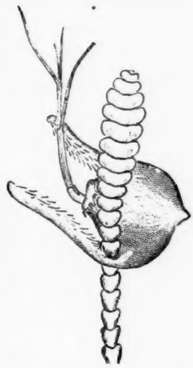

Fig. 6. — Seedling with first leaves.

The cotyledon grows out little beyond the hypocotyl, and is quickly outstripped by the ensheathed plumule, which turns upward and shortly unfolds to the waves several grass-like leaves (Fig. 6). Henceforth it is these leaves only which grow upward; for, except for the slender peduncle which bears the inflorescence, the only stem of the mature Phyllospadix is a creeping rootstock, or rhizome.

Our seedling (Fig. 6) has now quite a start in life, and yet it has no root. Its leaves, meanwhile, whipped back and forth by the waves, are gradually beaten to shreds, and replaced by others. In this way several of the first leaves may have lived and died before any root appears. At last, when roots are put forth, there are two of them produced, not from the hypocotyl, as we might expect, but from the stem above the cotyledon (*r*, Fig. 7). That is to say, these are, in the technical sense, adventitious roots. When full grown the roots are about two centimeters long, stout, and unbranched. This first pair hang down, one on either side of the stem, and are soon followed by several more which grow out from the second internode.

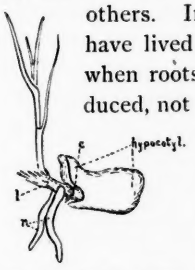

Fig. 7. — Young seedling with coats removed. *c*, insertion and remnant of cotyledon; *l*, second node with remnant of leaf; *r*, roots.

When the roots are several millimeters long they begin to produce, near their tips, a dense, woolly covering of root-hairs, and when a root comes in contact with any object, — be it the stem of the Amphiroa (Fig. 8), the rock

beneath, or another root, — these rhizoidal hairs spread, as a closely adhering film of whitish fibers, over the surface touched, binding the root to it. The root-hairs assume fantastic shapes in order to conform with the irregularities of the rock. If a root has, by chance, entered the loose sand, it becomes enclosed in a compact cylinder of sand, bound together by the myriad of branching, interwoven hairs.

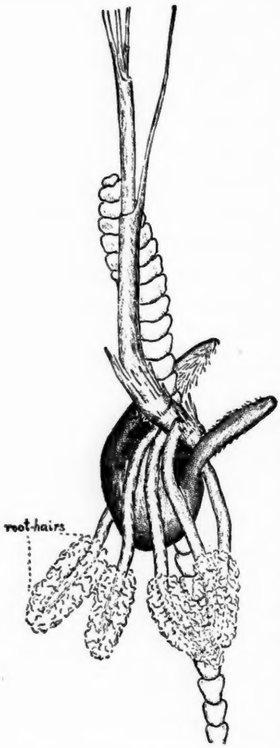

FIG. 8. — Seedling (older) with roots.

The plant has now taken a firm hold on life. Supposing that the start has been made aloft in the branches of the Amphiroa, the elongating stem now dips downward till it strikes the rock. Thenceforth it creeps along, taking, as it goes, a firm grip upon every inch. At each node it bears a leaf, and each of the short internodes produces, on one side a supra-axillary bud, and on the other what Professor Dudley[1] has aptly termed an "epaulette" of six or eight roots; alternating, so that, if one internode has its roots on the right side, the next will have roots on the left. Thus the stem, though in itself weak and brittle, keeps a close, broad grasp upon the rock, while the wiry leaves, buoyed by intercellular air-spaces, stream upward sometimes for a length of two meters. Before these leaves have been whipped to tatters by the waves, their place is supplied with new ones from the lateral buds.

When the rhizome has reached a length of, often, only one or two decimeters, it begins to die away behind. At the same time the lateral buds begin to push out for themselves, so that

[1] *Cf.* Dudley, R. W., in *Zoe*, vol. iv, p. 381.

as the parent stem creeps on it leaves on either side of its trail a series of new rhizomes, starting out at right angles to the old one. In like manner this new generation of rhizomes branch and rebranch, growing over and upon one another, till, in a few years, the bowlders, as well as the bed-rock, are covered by a patch of eelgrass, — a thick mattress, which, as it lies in sinuous tangles at low tide, quite dissipates the force of a hammer, though swung with all the energy of an enthusiastic botanist, and so must, one would think, considerably lessen the effect of the forces which are ordinarily at work reducing the bowlders to pebbles and grinding down the rock itself.

This brings us to the second phase of our subject, namely, the significance of such a plant as Phyllospadix to the geologist. What we wish to show is that under some conditions the effects of the plant in modifying the results of wave and current action are worthy of consideration.

Various geological authorities have commented upon the protection afforded to shore rocks by some marine plants, and upon the accumulation of detritus by others. Certainly no plant is better adapted to either of these functions than Phyllospadix. In the first place its manner of growth is exceptional, resulting, as it does, in the formation of a broad, continuous patch, instead of a scattering of individuals. Again, unlike the soft or rubbery fronds of the algæ, its leaves are strengthened by extremely tough bands of collenchyma fibers.

A moment ago we noticed how the eelgrass bed, the growth of which from a seedling we have sketched, covers the bowlders with a thick mattress which must prevent attrition between the loose stones and pebbles. At Bodega Bay may be seen such a bed, where, at low tide, one may stumble for rods along a bowlder-strewn shore without seeing the rock under foot, all being overlaid by the tangled mat of eelgrass. Now, it might be objected that the corrosive action of the acids excreted by root-hairs would offset the protection the plant might afford to the rock. But it is at once obvious that the root-hairs of Phyllospadix are, in this respect, unlike those of most plants. Their essential function is that of attachment, not nutrition, and, of course, if they should cut the ground from under their

own feet, so to speak, by dissolving away the rock to which they ought to hold fast, they would be useless.

Suppose, now, that a wave-cut terrace, which is being widened by the inroads of the sea, and which is swept by a littoral current bearing the shore-drift along with it, becomes overspread by a growth of coralline algæ. Geike, in his *Text-Book of Geology*, speaks of the preservation of shore rocks by the overgrowth of these corallines ("calcareous nullipores"). These plants cover the substratum with a brittle, calcareous crust, which, though a considerable protection against the cutting of water-borne sand, is shattered by the blow of a pebble. This calcareous enameling retards, to some extent, the lowering of the terrace by the sand-bearing current. That is, while the terrace widens, the water above it may remain comparatively shallow. Moreover, many of these corallines, as Amphiroa and Corallina, produce, in addition to the calcareous crust, numerous erect, jointed fronds; and the latter, as we have seen, offer the best possible lodging place for Phyllospadix. Here, then, we have the conditions most favorable to Phyllospadix, — shallow, but not quiet, water, and corallines to anchor the seeds.

Gradually, if there is eelgrass within drifting distance, the terrace becomes dotted with green tufts, the tufts spread into patches, and ultimately the higher border of the terrace presents, at low tide, the appearance of a wind-laid hay-field, the "grass," one to two meters long, lying in prostrate tangles.

Now begins the accumulation of debris. Stones and pebbles being carried alongshore by the current, odds and ends of seaweeds, and all the multifarious small drift of the shore, are caught in the network of rhizomes and wiry leaves. The larger stones may themselves serve as footholds upon which the rhizomes climb higher and wave their leaves higher in the water. Every stone entangled serves to stop more pebbles and sand, and, as the mass continues to pile up, the rhizomes are at last buried deep under it; but as long as the tips of the leaves wave free the plant thrives. On almost any of our beaches there may be found between tide-lines tufts of slender leaves apparently growing in the sand, but in reality anchored to the rock a meter, perhaps, below.

The result of the accumulations, then, is that the water is made shallower, so that, though the pounding of the heavy seas upon the shore is lessened, the waves still race in over the shallows and carry up the smaller particles to deposit them on the beach. At the same time, even though the littoral drift be not held permanently by the eelgrass, yet the time required for it to pass the place, and hence its chance of contributing to the beach, is increased.

Shoaler and shoaler grows the water, the shore line advancing as a low beach, and finally, — the littoral current being deflected seaward and the wave deposition continuing, — the terrace that was is overlaid by a sand-flat.

That the long, hemp-like fibers of eelgrass lend coherence to the mass of sand and stones in which they are imbedded is attested by the fact that where, as above, we find a clump of eelgrass half-buried in the sand, the level of sand within the clump is often several inches above that of the surrounding beach.

In closing, and to recapitulate, it seems probable that the spreading over a terrace of such a plant as Phyllospadix must tend, first, to protect the rocks from erosion and attrition; second, to help, by trapping the shore-drift, to raise the terrace so as to form a beach, or a sublittoral sand-flat; and last, by binding together its materials, to render the foundation of the beach, once formed, more coherent and stable.

University of California, Berkeley, Cal.,
May, 1900.

A QUANTITATIVE STUDY OF VARIATION IN THE BRACTS, RAYS, AND DISK FLORETS OF ASTER SHORTII HOOK., A. NOVÆ-ANGLIÆ L., A. PUNICEUS L., AND A. PRENANTHOIDES MUHL., FROM YELLOW SPRINGS, OHIO.[1]

GEORGE HARRISON SHULL.

CONTENTS.

I. Introduction.

The work upon which this paper is based was done in the Biological Laboratory of Antioch College, during the academic year 1900–1901, under the direction of Prof. W. L. Tower.

My primary object was to study the variations of several species of Aster by means of the statistical methods, to determine whether the results of Ludwig ('95, '96, '98) upon *Chrysanthemum leucanthemum* L. were also true for other nearly allied forms, and to find out, if possible, how much correlation there

[1] *Contributions from the Biological Laboratory of Antioch College*, No. 5.

is between the observed variation and the environment, or between parts of the same plant. Secondarily, it was hoped that this research might show something of the applicability of these methods to taxonomic or monographic work in a genus so difficult from the systematic standpoint as Aster.

II. MATERIAL.

This consisted of the blooming capitula of *Aster shortii* Hook., *A. novæ-angliæ* L., *A. puniceus* L., and *A. prenanthoides* Muhl.

The capitula were cut off without any conscious selection, folded in papers, labeled, and preserved in alcohol. With the exception of those plants where series of pickings were made, the stems from which the capitula had been gathered were preserved for future reference.

All of the species of Aster studied are perennial, but they differ in the manner in which the annual stems are produced. In the following description of the material used in this study I shall use the term "individual" in its broader sense, including all stems which have been derived from a single seed.

Aster shortii Hook. has from one to three or four slender annual stems arising from a small perennial root. The material which forms the basis for the study of this species was obtained Sept. 26, 1900, and consisted of 226 capitula from three isolated individuals and from a group of ten stems growing near to each other. The stems of this group were probably mostly distinct individuals, though they may have been of close genetic relationship. These plants grew in the thin limestone soil at the foot of the Niagara limestone cliffs bordering the northern end of Sheldon's Glen, one-half mile southeast of Yellow Springs, Ohio.

Aster novæ-angliæ L. has a heavy mass of perennial roots, and from the base of the annual stems of one year's growth may arise a considerable number of heavy stems of the next year's growth, forming a clump. The 199 capitula used in the study of this species were collected Sept. 30, 1900, from five individuals growing in the flood plain of a tributary to the Glen

Stream, one-half mile east of Yellow Springs, and from four individuals similarly located in the valley of the Glen Stream about forty rods above the point at which it empties into the Little Miami River, one mile southeast of Yellow Springs, Ohio.

The manner of production of annual stems in *Aster puniceus* L. resembles closely that of *Aster novæ-angliæ* L. The material of *Aster puniceus* L. used in this study was collected Sept. 25, 1900. It consisted of 798 capitula from thirteen stems arising from three perennial roots growing at the margin of a bog five miles west of Yellow Springs, Ohio. These three individuals were identically located, being separated by a space of but a few yards. Environmental conditions had, therefore, no known influence in determining the differences in the heads from the three clumps.

Aster prenanthoides Muhl. differs from all of the other species studied, in the manner in which its annual stems are produced. It sends out slender rootstocks, which give rise to new stems at a little distance from the old ones, thus forming patches with the stems growing singly.

Eighty-three capitula of *Aster prenanthoides* Muhl. were collected Sept. 27, 1900, from seven stems, apparently belonging to two individuals. The remaining material of this species, making a total of 658 capitula, was all collected from a single small plot. Four successive collections were made on September 27, September 30, October 4, and October 8, 1900. All the capitula which were blooming at the time of each collection were taken, amounting respectively to 117, 143, 139, and 176 heads, and comprising all the heads produced by the selected plot during the season. The object in collecting in this way was to test, at least within narrow limits, the constancy of the variability "constants" throughout the flowering season.

The plants from which all the material of *A. prenanthoides* Muhl. was collected grew at the bottom of a small ravine near Clifton, Ohio, at the margin of a permanent stream, so that heat, light, soil, and moisture conditions were nearly constant throughout the growing period.

III. METHODS AND PRECAUTIONS.

In order that the personal equation should modify results as little as possible, all of the heads of each individual were collected, and none were discarded on the ground of abmodality. The only material rejected was such as was eaten by insects, or had been blighted to such extent as to make a correct count impossible. It is evident that by the discarding of healthy material because of its great departure from the usual condition, or, as Strong (**1901**, p. 295) says, the choice of "individuals which appear on inspection to be typical," the statistical method may be made to give any result for which the investigator may be looking.

There is one element of error in the choice of material which must be mentioned. In those cases in which it seemed desirable to get curves and "constants," representing the conditions in the capitula of single individuals, there was necessarily a choice of those individuals which had the largest number of blooming heads. In this respect, therefore, the determinations would represent the conditions in the more robust specimens rather than in the general population. To counteract this tendency, there was an occasional collection of material from a sufficiently large group of smaller individuals to give equally valid results. As these collections from a number of smaller individuals did not show a marked difference from those of single larger individuals, this selection has probably not greatly modified the results.

In making counts the liability of error is not so great as in the taking of measurements. However, even in counting there are sources of error, which I found it necessary to eliminate as far as possible. To free my work as far as possible from these sources of error, the capitula were carefully dissected and the parts kept separate until the count was completed. When there was the least doubt as to the correctness of the result they were recounted. Also in cases of great abmodality the results were verified by a recount.

In calculating the various constants I have used the formulæ given by Davenport (**'99**). All the mathematical processes

were carried out to the tenth decimal place, and wherever practicable they were checked. It is probable, therefore, that all calculations are correct to the fifth decimal place.

In plotting the variations I have used the "method of rectangles" as best representing the actual conditions found. In those cases in which material was insufficient compared with the range of variation, I have doubled the classes, but in no case have I grouped more than two classes together. In this way the essential features of the curves have remained unchanged, while the lesser irregularities have been eliminated.

It must be remarked, however, in regard to the grouping of classes, that the method should be used with much caution. By combining a sufficient number of classes every multimodal curve may be made monomodal.

It is also essential, in doubling, that a definite plan be adopted in order that the results may be comparable. The writer followed the plan of throwing together the two classes nearest the mean. As the mean is a constant, this makes the resulting double classes of the various curves strictly comparable. If I had begun at the lower limit of range instead of at the mean, the count of one more variate might have lowered the range by one, and thus have changed the combinations, with the result that the character of the curve might be much modified.

IV. Results.

Aster shortii Hook. — Fig. 1 represents the frequency polygon of the bracts. The range, 28 to 49, was so great that the 226 counts were insufficient, and it was deemed best to double the classes. In this way the curve becomes monomodal, with the mode on 36–37, and the mean on 36.800884. The coefficient of variability was 10.727157.

The frequency curve of the rays (Fig. 2) shows a remarkably strong mode on 13, 38 per cent of the variates falling into that class, with the mean on 14. This strong mode on 13 suggests at once Ludwig's ('95, '96, '98) interesting results on *Chrysanthemum leucanthemum* L., etc.; but, as nowhere else in the Asters studied has there been any apparent tendency of modes

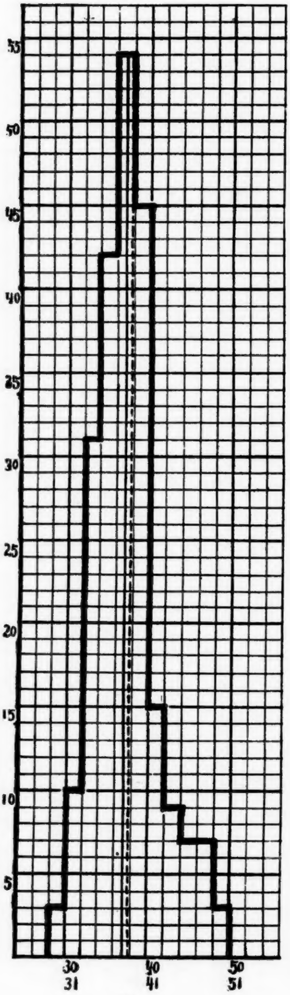

Fig. 1.

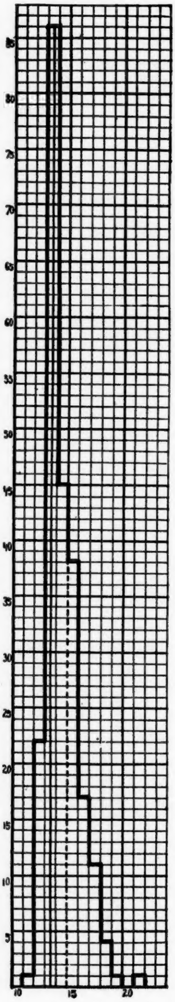

Fig. 2.

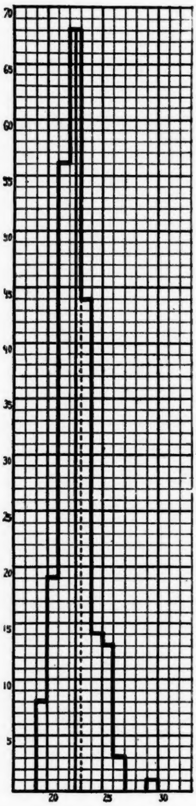

Fig. 3.

Fig. 1. — *Aster shortii* Hook. Bract curve of 226 heads. Classes doubled. Mean = 36.800884 ± .177121 ; mode = 36–37 ; σ = 3.947688 ± .125243.

Fig. 2. — *Aster shortii* Hook. Ray curve of 226 heads. Mean = 14 ± .068448 ; mode = 13 ; σ = 1.525592 ± .048400.

Fig. 3. — *Aster shortii* Hook. Disk curve of 226 heads. Mean = 22.053097 ± .067885 ; mode = 22 ; σ = 1.513025 ± .048001.

to fall into the series 8, 13, 21, 34, etc., this condition in *Aster shortii* Hook. cannot be considered as having any special sig-

	X_2	−8	−7	−6	−5	−4	−3	−2	−1	0	0	1	2	3	4	5	6	7	8	9	10	11	12
X_1		28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
−3	11											1											
−2	12				1	1	2	3	4	3	4	3	1				1						
−1	13		1	3	2	9	4	7	7	18	10	8	9	6	1								
0	14	1		1		2	4	5	2	4	4	6	10	3	2		1						
1	15		1	1	2	4	1	2	5	3	6	1	4			2	1	3		2			
2	16					3	1		3				2	2		1	1	1	1			2	
3	17							3	1	1	1				1	1				3			
4	18															1			1		1		1
5	19																		1				
6	20																						
7	21																				1		

FIG. 4. — *Aster shortii* Hook. Correlation surface for 226 heads. Rays subject and bracts relative. $\rho = .549555 \pm .025157$.

	X_2	−3	−2	−1	0	0	1	2	3	4	5	6
X_1		19	20	21	22	23	24	25	26	27	28	29
−3	11					1						
−2	12		1	7	6	7	1					
−1	13	3	2	23	37	18	2	1				
0	14	3	6	8	13	8	5	2				
1	15	2	4	12	6	5	2	5	2			
2	16		4	4	1	2	2	3	1			
3	17		2	1	2	3	2	1				
4	18			1	2							1
5	19				1							
6	20											
7	21							1				

FIG. 5. — *Aster shortii* Hook. Correlation surface for 226 heads. Rays subject and disk florets relative. $\rho = .446645 \pm .029861$.

nificance in this connection. The coefficient of variability for the rays was found to be 10.897091, or a little greater than that of the bracts.

The curve of the disk florets (Fig. 3) in this species shows a remarkable lack of variation in parts which, owing to their indeterminate character, might be expected to be the most variable. The mode is on 22, the mean on 22.053097, and the coefficient of variability is only 6.860830. It should be noted that in all these curves there is negative skewness,[1] though it is slight in the bracts and disk florets. The variability constants for *Aster shortii* Hook. are shown in the following table.

TABLE A. — CONSTANTS OF ASTER SHORTII HOOK.

	BRACTS.	RAYS.	DISK FLORETS.
No.	226	226	226
Mean	36.800884	14	22.053097
Mode	36–37	13	22
A. D.	3.029211	1.176991	1.115200
σ	3.947688	1.525592	1.513025
P. E. A. D.	± 2.662716	± 1.029012	± 1.020535
P. E. M.	± .177121	± .068448	± .067885
P. E. σ	± .125243	± .048400	± .048001
C. V.	10.727157	10.897091	6.860830

In Fig. 4 is represented a "correlation surface" with rays subject and bracts relative. The coefficient of correlation was found to be .549555 (P. E. $\rho = \pm$ .025157). The correlation between rays and disk florets is shown in Fig. 5, in which the coefficient of correlation is .446645 (P. E. $\rho = \pm$ .029861).

Aster novæ-angliæ L. — In this species the range of variation in all the parts was great, the least range, 30 to 60, occurring in the bracts.

All the frequency polygons, Figs. 6, 7, and 8, show a multimodal condition, but this may be due to too scanty material. Although no dependence can be put upon the multimodal condition of these curves, the "variability constants" will perhaps not differ widely from results which would be given

[1] The degree of skewness has not been computed for any of the polygons of distribution because the range of material was too small to make this index of any value.

by counting larger quantities of the same material. These appear in the following table.

TABLE B. — CONSTANTS OF ASTER NOVÆ-ANGLIÆ L.[1]

	BRACTS.	RAYS.	DISK FLORETS.
No.	199	199	199
Mean	44.030150	42.874371	62.452261
Modes	33, 37, 43, 47, 57	37, 43, 47, 51	51, 60, 63, 70
A. D.	4.111310	5.048407	7.688088
σ	5.212961	6.308112	9.314270
P. E. A. D.	± 3.516142	± 4.254822	± 6.282475
P. E. M.	± .249252	± .301616	± .445352
P. E. σ	± .176248	± .213267	± .314912
C. V.	11.839527	14.710682	14.914224

There is a high degree of correlation between rays and bracts (Fig. 9), which is the more apparent because of the close agreement in the number of rays and bracts; 10.54 per cent of all the capitula had the number of rays and bracts equal. The coefficient of correlation between these was .802388 ± .012685. Between rays and disk florets the correlation (Fig. 10) was much lower, the coefficient being .594798 ± .024859.

Aster puniceus L. — The polygons of distribution of the bracts (Fig. 11), rays (Fig. 12), and disk florets (Fig. 13) of *Aster puniceus* L. are all multimodal; but it would not be fair to assume that this condition is a specific one, for, although the number of variates was 798, they represent only three individuals, and these individuals had an exceedingly wide range of variation and also differed widely in the values of their "constants." These facts will be best appreciated by a study of the table on the following page.

[1] The table of constants for *Aster novæ-angliæ* L. is presented because the multimodal condition of the polygons of distribution of this species may be due to too limited material. If more material shows this same condition, then all the constants except the mean and mode must be dropped from this table. The same is also true for the constants for all of the species given in this paper.

TABLE C. — CONSTANTS OF ASTER PUNICEUS L.

		INDIVIDUAL No. 1. 337 heads.	INDIVIDUAL No. 2. 246 heads.	INDIVIDUAL No. 3. 215 heads.	SUMMATION, Nos. 1, 2, and 3. 798 heads.
BRACTS.	Mean . . .	42.501483	45.378048	46.795348	44.546365
	Modes . .				35, 39, 49, 46, 48
	A. D. . . .	3.965747	3.140095	2.377501	3.571510
	σ	4.760197	3.959072	3.035446	4.497254
	P. E. A. D.	± 3.210752	± 2.670394	± 2.047408	± 3.033397
	P. E. M. . .	± .174901	± .170258	± .139632	± .107381
	P. E. σ . .	± .123673	± .120390	± .098734	± .075929
	C. V. . . .	11.200072	8.724641	6.486640	10.095669
RAYS.	Mean . . .	35.020771	36.321138	39.660465	36.671679
	Modes . .				27, 35, 37
	A. D. . . .	3.039368	3.421607	3.175164	3.577188
	σ	3.904214	4.297721	4.018685	4.480251
	P. E. A. D.	± 2.633392	± 2.898813	± 2.710603	± 3.021929
	P. E. M. . .	± .143450	± .184821	± .184861	± .106975
	P. E. σ . .	± .101434	± .130688	± .130716	± .075642
	C. V. . . .	11.148282	11.832838	10.132723	12.217198
DISK FLORETS.	Mean . . .	60.513353	76.609756	74.241860	69.174185
	Modes . .				57–58, 63–64, 67–68, 73–74, 79–80
	A. D. . . .	5.805756	8.068609	5.644478	8.947764
	σ	7.338405	10.083765	7.115330	11.116989
	P. E. A. D.	± 4.949754	± 6.801500	± 4.799290	± 7.498400
	P. E. M. .	± .269630	± .433647	± .327308	± .265440
	P. E. σ . .	± .190657	± .306628	± .231442	± .187694
	C. V. . . .	12.126919	13.162508	9.583987	16.071008

This work on *Aster puniceus* L. shows what a wide difference may exist, even in such constants as the means, standard deviations, and coefficients of variability, in individuals growing under apparently identical conditions.

In Fig. 14 is shown the correlation surface for rays and bracts of all the heads counted. The coefficient of correlation was .705100 ± .009194, while that for rays and disk (Fig. 15) was .674928 ± .010045.

Aster prenanthoides Muhl. — The frequency polygons for all the heads counted in this species are shown in Figs. 16, 17, and 18. All are multimodal, but by doubling the classes in Fig. 17, which represents the variation in the rays, the curve becomes monomodal with negative skewness, the mode being on 26–27 and the mean on 28.037993.

Doubling the classes in Fig. 16 still leaves three modes in the frequency polygon of the bracts. These modes occur on

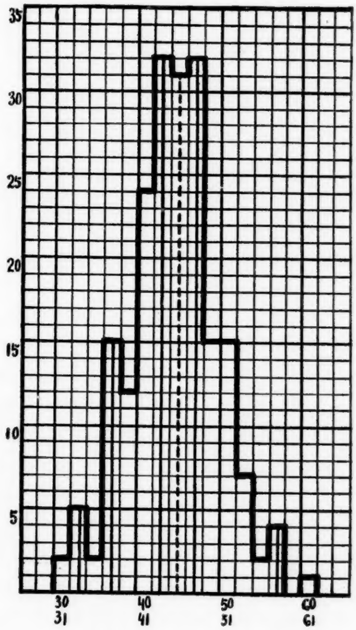

Fig. 6. — *Aster novæ-angliæ* L. Bract curve of 199 heads. Classes doubled. Mean = 44.030150 ± .249252; modes = 33, 37, 43, 47, 57; σ = 5.212961 ± .176248.

40–41, 44–45, and 48–49. Fig. 18 shows the curve of the disk florets to have two nearly equal modes on 48–49 and 52–53.

The correlation of rays and bracts in the 658 capitula counted (Fig. 19) is expressed by the coefficient .776834 ± .007820, and that of the rays and disk florets (Fig. 20) by .770316 ± .008042.

TABLE D. — CONSTANTS OF ASTER PRENANTHOIDES MUHL.

	BRACTS.	RAYS.	DISK FLORETS.
No.	658	658	658
Mean	44.044072	28.037993	50.297872
Mode	40–41 44–45 48–49	26–27	48–49 52–53
A. D.	4.497002	3.373227	4.884951
σ	5.716510	4.070071	6.310315
P. E. A. D.	± 3.855786	± 2.745263	± 4.256308
P. E. M.	± .150314	± .107021	± .165889
P. E. σ	± .106288	± .075675	± .117301
C. V.	12.979068	14.516272	12.545890

Result of the Successive Collections. — The remaining figures represent the conditions found in four successive pickings made from a single group of individuals of *Aster prenanthoides* Muhl.

1. *Bracts.* Figs. 21, 22, 23, and 24 show the frequency polygons of the bracts in the successive collections. In the first collection (Fig. 21) there was a single mode on 49–50, with the mean on 47.410256 and a strong positive skewness. In the second collection (Fig. 22) the curve broke up into three modes on 40–41, 44–45, and 48–51, while the mean fell to 44.342657. In the third collection (Fig. 23) the material exhibited two modes on 44–45 and 50–51, which correspond closely with the upper two modes of the second picking, the mean having fallen to 43.834532. At the last collection the curve, given in Fig. 24, showed a strong mode on 41–42, while the upper mode, which at this time occurred on 49–50, had become much less prominent, and a small mode had appeared on 33–34. The mean had continued to fall, and in this last collection was only 41.92045.

The table on page 124 will facilitate a comparison of the bracts from the four collections.

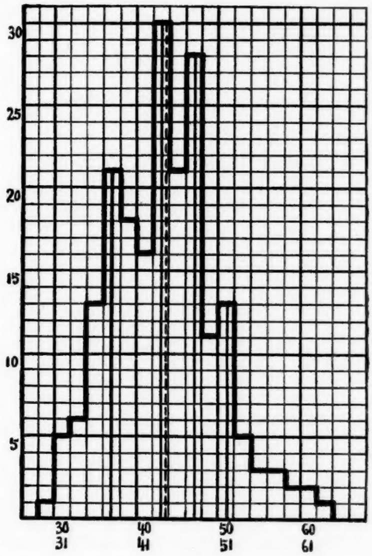

Fig. 7. — *Aster novæ-angliæ* L. Ray curve of 199 heads. Classes doubled. Mean = 42.874371 ± .301616; modes = 37, 43, 47, 51; $\sigma = 6.308112 \pm .213267$.

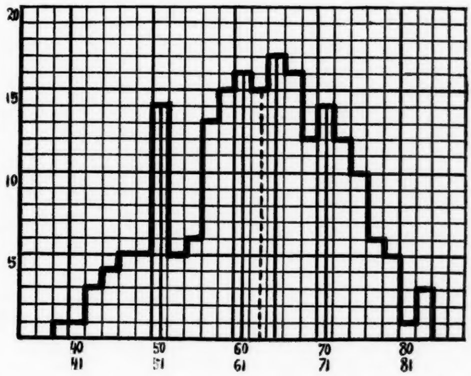

Fig. 8. — *Aster novæ-angliæ* L. Disk curve of 199 heads. Classes doubled. Mean = 62.452261 ± .445352; modes = 51, 60, 63, 70; $\sigma = 9.314270 \pm .314912$

TABLE E. — CONSTANTS OF BRACTS OF FOUR PICKINGS OF ASTER PRENANTHOIDES MUHL.

	117 CAPITULA, COLLECTED SEPTEMBER 27.	143 CAPITULA, COLLECTED SEPTEMBER 30.	139 CAPITULA, COLLECTED OCTOBER 4.	176 CAPITULA, COLLECTED OCTOBER 8.
Mean	47.410256	44.342657	43.834532	41.92045
Mode	49–50	40–41 44–45 48–51	44–45 50–51	33–34 41–42 49–50
A. D.	4.350646	4.256345	4.308211	3.855552
σ	5.524237	5.152370	5.275976	4.889626
P. E. A. D. . .	± 3.726098	± 3.475273	± 3.558646	± 3.298052
P. E. M. . . .	± .344540	± .290617	± .301840	± .248600
P. E. σ	± .243626	± .205497	± .213433	± .175786
C. V.	11.651989	11.619444	12.036119	11.664053

2. *Rays.* The frequency polygon for rays from the first collection (Fig. 25) shows a strong mode on 32–35 and a lesser mode on 26–27. The mean of this collection was 30.769230. In the second collection (Fig. 26) the principal mode had fallen to 30–33, filling up the sinus and forming a monomodal curve. The mean had also fallen to 28.706293. In the third collection the rays again broke up into a multimodal condition, as shown in Fig. 27. The modes of this curve are on 24–25, 28–29, and 32–33, and the mean on 28.251798. In the fourth collection the rays again exhibited a strongly monomodal condition (Fig. 28), with the mode on 26–27, while the mean had fallen to 26.335227.

3. *Disk Florets.* In Fig. 29 is shown the multimodal frequency polygon for the disk florets of the first collection, with modes on 56–57 and 60–61, and the mean on 56.427350. In the second collection (Fig. 30) modes occurred on 45–46 and 51–52, and the mean had fallen to 51.713286. In Fig. 31 is represented the variation of the disk florets of the third collection. The curve is monomodal and nearly normal, the mode occurring on 49–50 and the mean on 49.158273. The disk curve of the fourth collection (Fig. 32) is also strongly monomodal and nearly normal, but the mode has fallen to 45–46 and the mean to 45.778409.

	X_2	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
X		30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
-13	29	1																														
-12	30				1																											
-11	31		1		1		1	1																								
-10	32				1				1																							
-9	33				1			1			1	1																				
-8	34					1			1	2	1				1																	
-7	35								4		1		2																			
-6	36				1				1			4	2	2																		
-5	37							2	3		1			4		1																
-4	38											1	1	2	1		2															
-3	39									1	2	1			1	1	3	1			1											
-2	40													1	3	3																
-1	41								1		1		2	2		1	1			1												
0	42										1	1	2	1	3			3	1		1											
0	43										1	1		1	1	1	5	4	2		1											
1	44											1	1		1		2	2	2			1										
2	45															1	2	2	2	1	3											
3	46												1	2	1	1	3	2	4	1		1		1								
4	47											1	2			1			1			2	1	1	1		1					
5	48														1			1	1		1		1									
6	49																1	1	2					1			1					
7	50												1						1	2	1	2	1		1							
8	51													1								1	1		1							
9	52																				1							1				
10	53													1								2										
11	54																				1		1									
12	55														1																	
13	56																1							1				1				
14	57																															
15	58																1															1
16	59																															
17	60																											1				
18	61																											1				
19	62																															
20	63																					1										

FIG. 9. — *Aster novæ-angliæ* L. Correlation surface for 199 heads. Rays subject and bracts relative. $\rho = .802388 \pm .012685$.

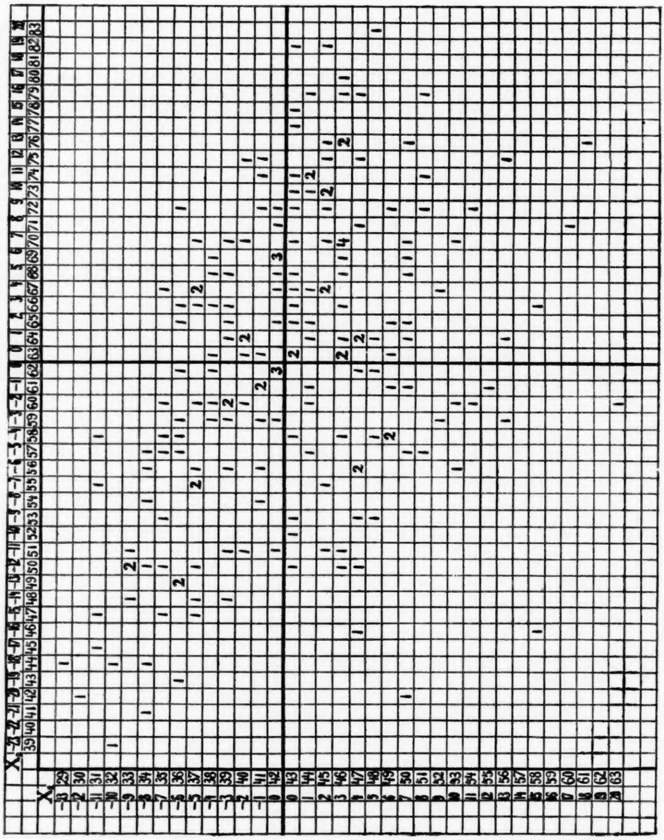

FIG. 10. — *Aster novæ-angliæ* L. Correlation surface for 199 heads. Rays subject and disk florets relative. $\rho = .594798 \pm .024859$.

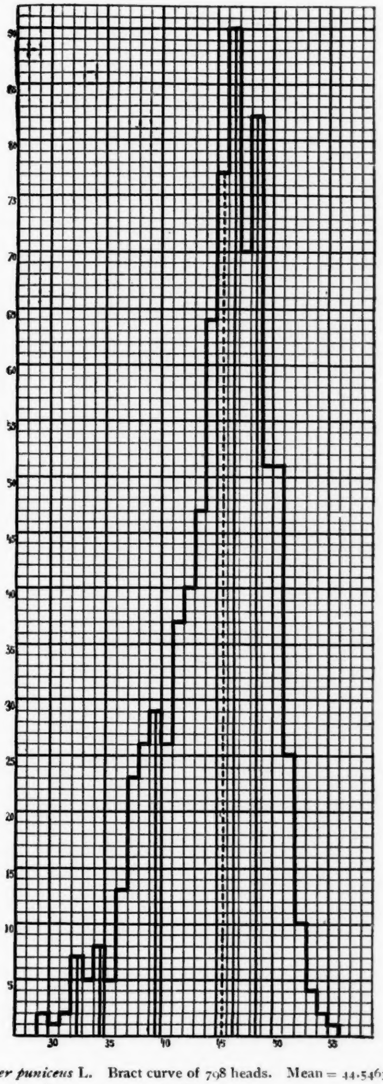

FIG. 11. — *Aster puniceus* L. Bract curve of 798 heads. Mean = 44.546365 ± .107381; modes = 32, 35, 39, 46, 48; σ = 4.497254 ± .075929.

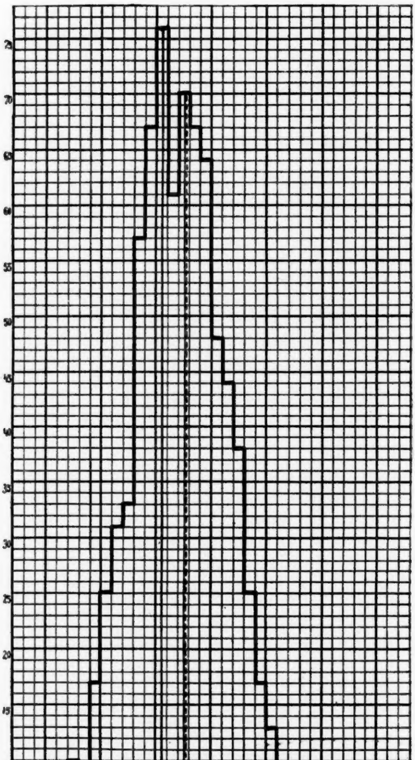

FIG. 12. — *Aster puniceus* L. Ray curve of 798 heads. Mean = 36.671679 ± .075642; modes = 27, 35, 37; σ = 4.480251 ± .075642.

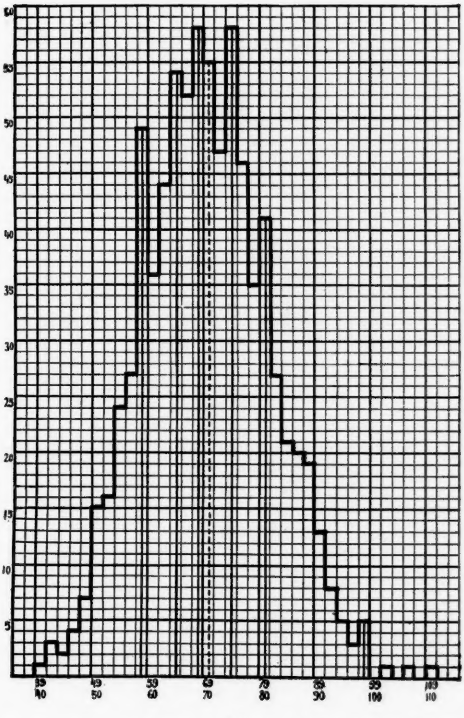

FIG. 13. — *Aster puniceus* L. Disk curve of 798 heads. Classes doubled. Mean = 69.174185 ± .265440; modes = 57-58, 63-64, 67-68, 73-74, 79-80; σ = 11.116989 ± .187694.

X_1 \ X_2		-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10
		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
-12	24		1				1																					
-11	25						1																					
-10	26			1							1				1													
-9	27			1		1		3	2	1		1	1															
-8	28	1			1			1	1			1	2						1		1							
-7	29	1			2		2			4	3	2				3												
-6	30				1	1	1			5	3	3	2		3	2	2	1	1									
-5	31				2	1			2	4	2	3	3	2	4	4		1	3									
-4	32				1	1			2	1	5	3	2	5	3	5	2		1	2								
-3	33					1	1			4	5	6	6	4	9	4	6	7	3		1							
-2	34						2	1	2	1	2	4	2	7	2	9	11	6	5	6	2	4			1			
-1	35								3	1	3	3	5	10	7	8	7	7	7	3	8	2	1	1				
0	36									2	2	2		3	4	4	6	5	16	6	4	3	2	1		1		
0	37								1			1		2	4	4	4	11	11	9	10	6	7					
1	38												1	2	1	2	7	10	10	15	7	4	3	4		1		
2	39												2			2	8	13	13	4	11	3	5	2	1			
3	40													1	1		5	5	4	5	6	7	7	5	2			
4	41													1			2	2	5	5	10	5	5	5	3			
5	42														1		3	4	2	8	9	6	2	3				
6	43																	2	3	3	5	4	4	2	2			
7	44																	1	1	1	4	1	9					
8	45																1		2	2	2	3	2	1				
9	46																	1			1	1	3					
10	47																			1	1	2			1		1	
11	48																		1				1					1
12	49																									1	1	
13	50																		1									
14	51																							1				
15	52																											
16	53																											
17	54																											
18	55																									1		

FIG. 14. — *Aster puniceus* L. Correlation surface for 798 heads. Rays subject and bracts relative.
$\rho = .705100 \pm .009194$.

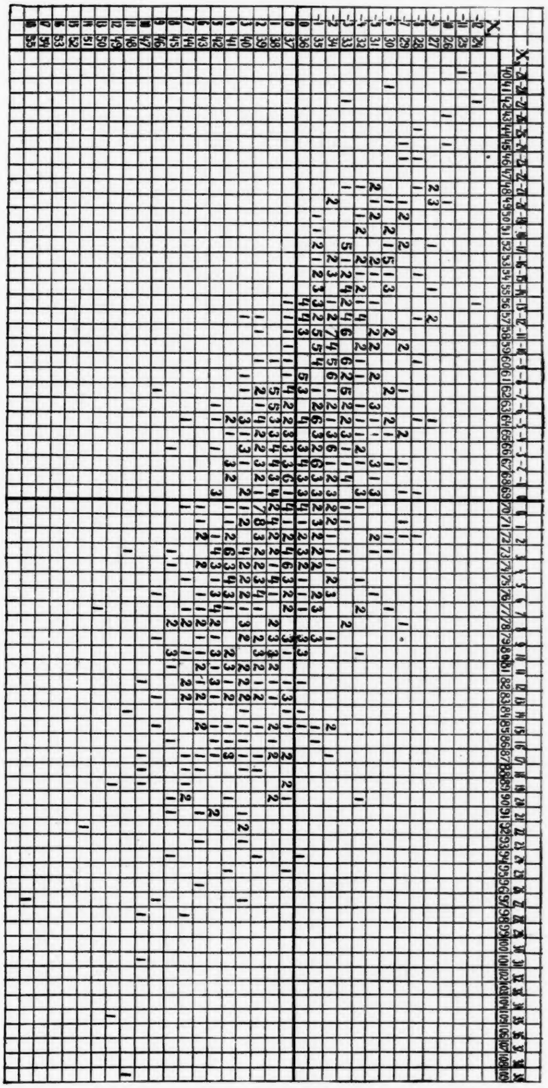

Fig. 15. — *Aster puniceus* L. Correlation surface for 798 heads. Rays subject and disk florets relative. $\rho = .674928 \pm .010045$.

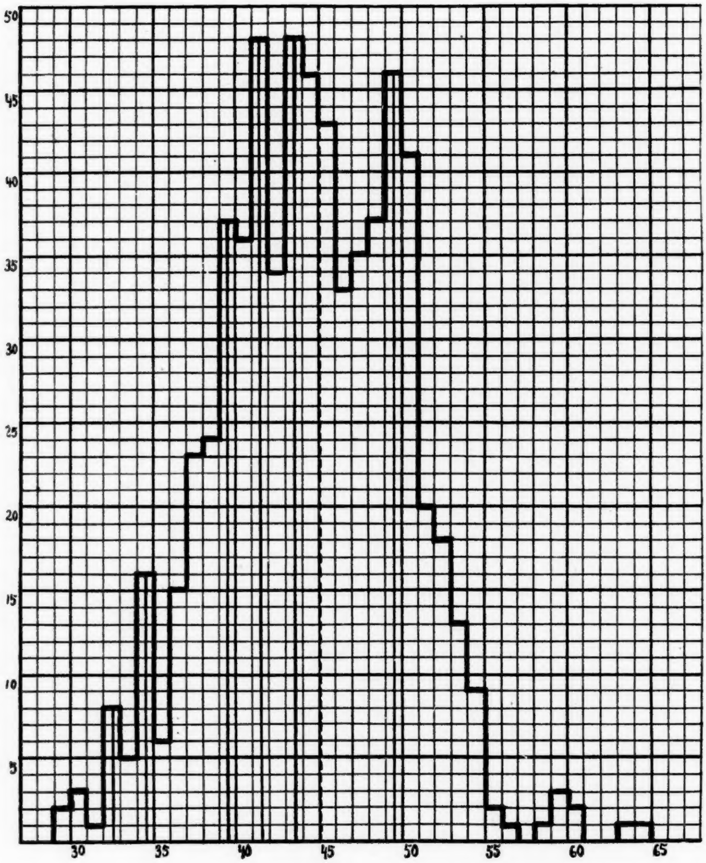

FIG. 16. — *Aster prenanthoides* Muhl. Bract curve of 658 heads. Mean = 44.044072 ± .150314; modes = 32, 34, 39, 41, 43, 49; σ = 5.716510 ± .106288.

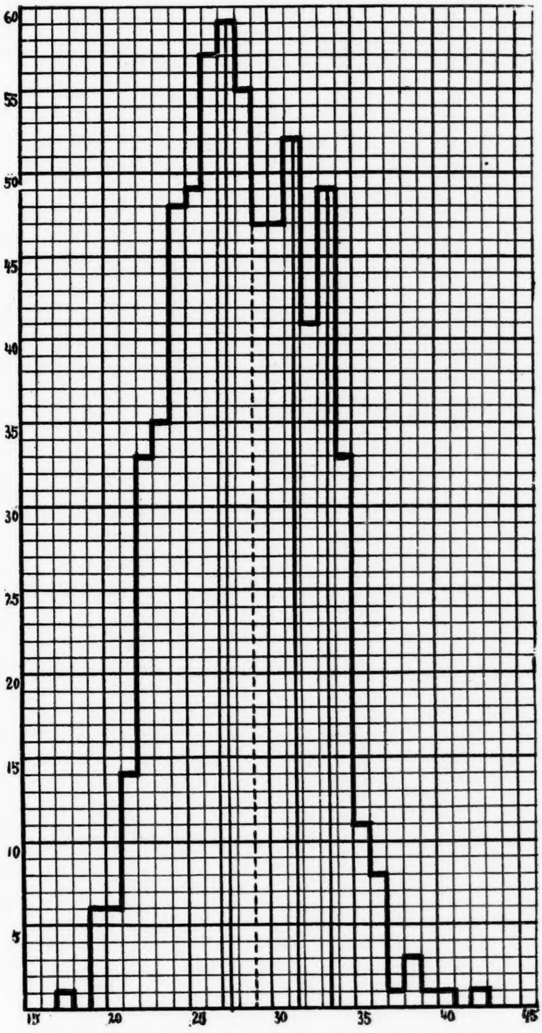

FIG. 17. — *Aster prenanthoides* Muhl. Ray curve of 658 heads. Mean = 28.037993 ± .107021; modes = 27, 31, 33; $\sigma = 4.070071 \pm .075675$.

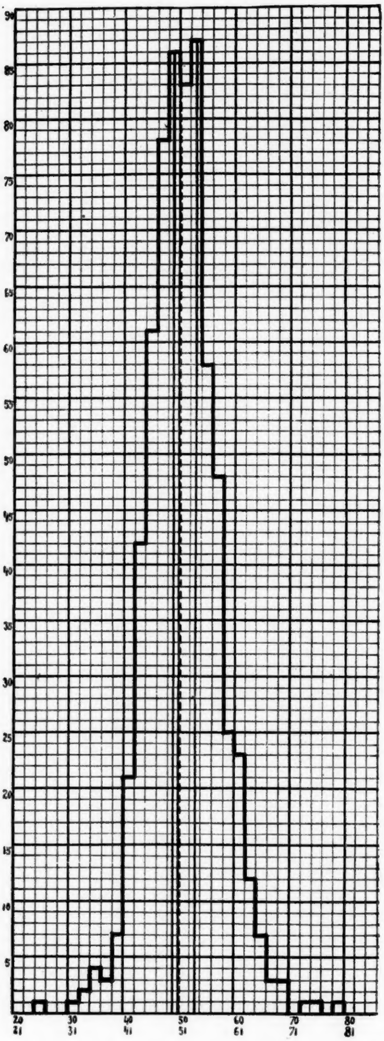

Fig. 18. — *Aster prenanthoides* Muhl. Disk curve of 658 heads. Classes doubled. Mean = 50.297872 ± .165889; modes 48–49, 52–53; σ = 6.310315 ± .117301.

X_1	X_2	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
-11	17				1																																
-10	18																																				
-9	19	1					2			3																											
-8	20						1			3	2																										
-7	21	1	2	1			3		2		2	2				1																					
-6	22				3	3	3	3	4	1	5	4	2	1	1	2	1																				
-5	23				2		3	1	4	4	5	6	3	5			1	1																			
-4	24					2	2	1	5	3	2	7	8	7	2	6	1	2																			
-3	25				1		2			3	5	13	7	5	6	2	2		1	2																	
-2	26									2	3	4	8	10	10	7	8	2	1		2																
-1	27				1					2		1	7	8	8	12	10	7		1			1			1											
0	28									1				6	4	11	12	7	5	4		3					1	1									
0	29													5	1	4	4	9	8	6	6	3	1														
1	30												1	1		2	4	7	5	9	7	7	3				1										
2	31															1	3	4	7	4	8	10	7	4	1	2		1									
3	32									1					1			3	1	4	6	7	9	1	6		2										
4	33							1							1			1	3	2	6	7	13	8	3	2	1				1						
5	34																		1	2	2	9	4	4	4	3	2		1				1				
6	35																			1			3	2	2	3											
7	36		1																1					1	1	1	1					2					
8	37																										1										
9	38																								1	1						1					
10	39																																				1
11	40																																1				
12	41																																				
13	42																																			1	

FIG. 19. — *Aster prenanthoides* Muhl. Correlation surface for 658 heads. Rays subject and bracts relative. $\rho = .776834 \pm .007820$.

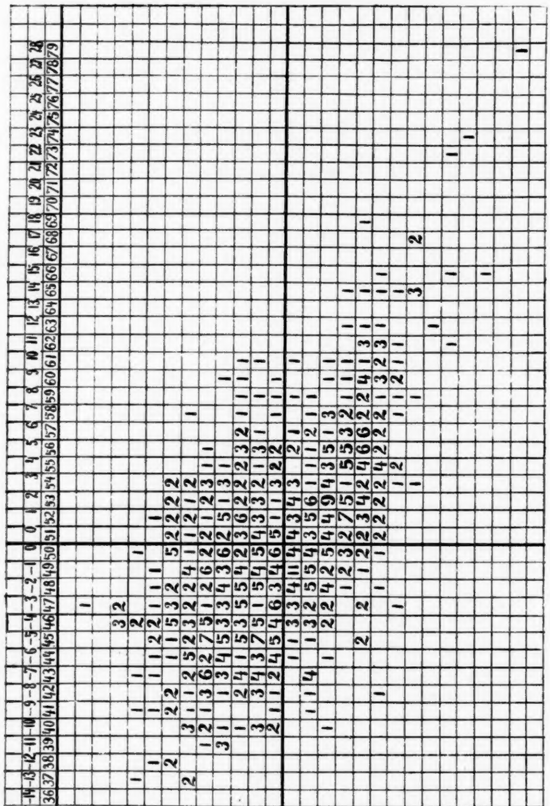

FIG. 20. — *Aster prenanthoides* Muhl. Correlation surface for 658 heads. Rays subject and disk florets relative. $\rho = .770316 \pm .008042$.

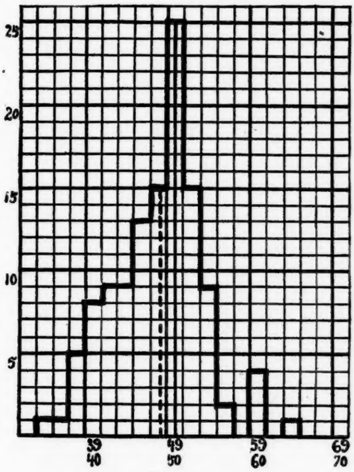

Fig. 21.

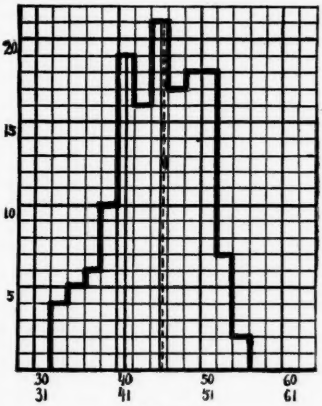

Fig. 22.

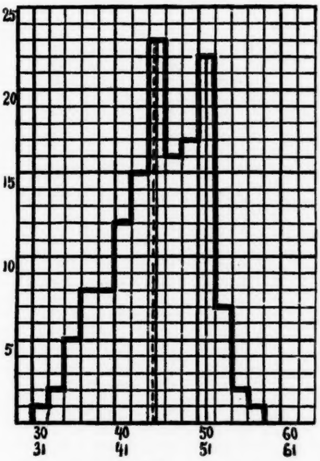

Fig. 23.

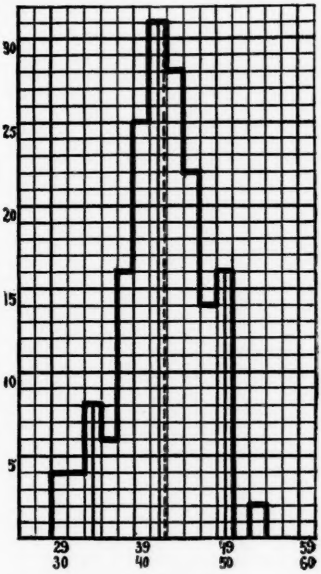

Fig. 24.

Fig. 21. — *Aster prenanthoides* Muhl. Bract curve of 117 heads collected September 27. Classes doubled. Mean = 47.410256 ± .344540; mode = 49–50; σ = 5.524237 ± .243626.

Fig. 22. — *Aster prenanthoides* Muhl. Bract curve of 143 heads collected on September 30. Classes doubled. Mean = 44.342657 ± .290617; modes 40–41, 44–45, 48–51; σ = 5.152370 ± .205497.

Fig. 23. — *Aster prenanthoides* Muhl. Bract curve of 139 heads collected on October 4. Classes doubled. Mean = 43.834532 ± 301.840; modes, 44–45, 50–51; σ = 5.275976 ± .213433.

Fig. 24. — *Aster prenanthoides* Muhl. Bract curve of 176 heads collected on October 8. Classes doubled. Mean = 41.92045 ± .248600; modes = 33–34, 41–42, 49–50; σ = 4.889626 ± .175786.

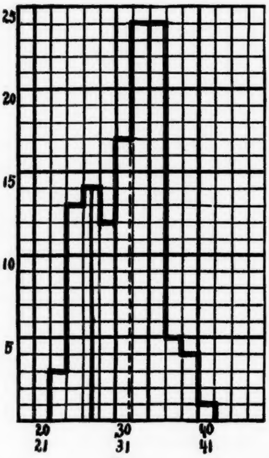

FIG. 25.

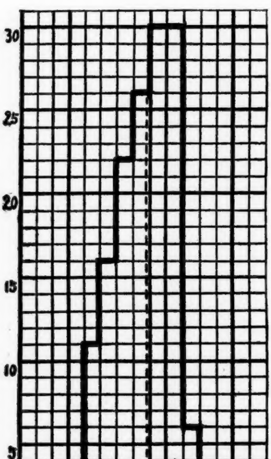

FIG. 26.

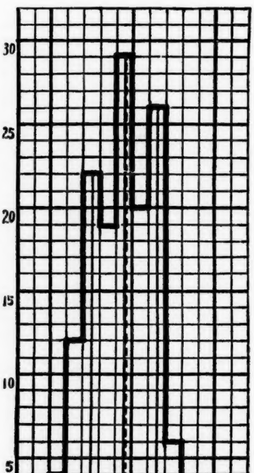

FIG. 27.

FIG. 25. — *Aster prenanthoides* Muhl. Ray curve of 117 heads collected on September 27. Classes doubled. Mean = 30.769230 ± .248547; mode = 26–27, 32–35; σ = 3.985839 ± .175749.

FIG. 26. — *Aster prenanthoides* Muhl. Ray curve of 143 heads collected on September 30. Classes doubled. Mean = 28.706293 ± .201316; mode = 30–33; σ = 3.569141 ± .142351.

FIG. 27. — *Aster prenanthoides* Muhl. Ray curve of 139 heads collected on October 4. Classes doubled. Mean = 28.251798 ± .200320; modes = 24–25, 28–29, 32–33; σ = 3.501476 ± .141641.

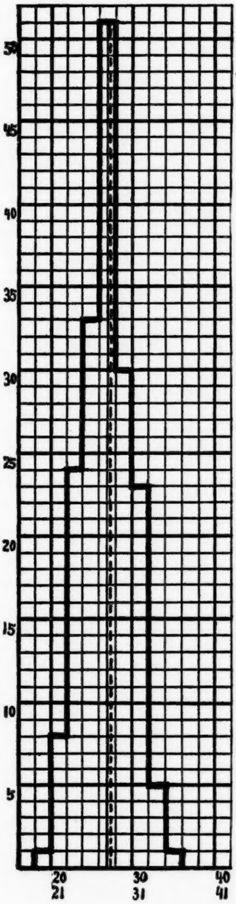

Fig. 28.

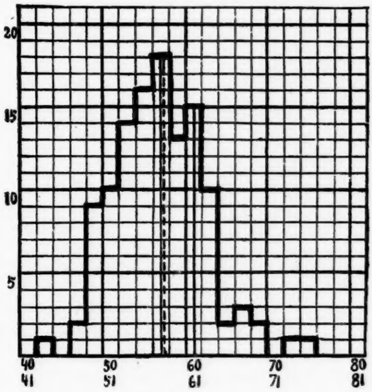

Fig. 29.

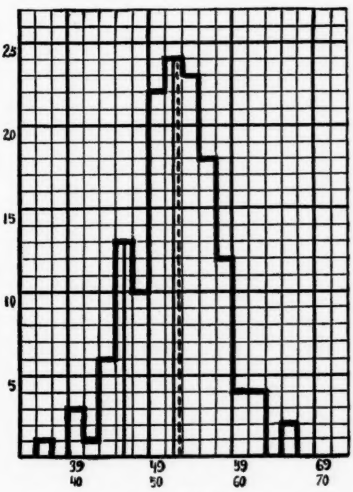

Fig. 30.

Fig. 28. — *Aster prenanthoides* Muhl. Ray curve of 176 heads collected on October 8. Classes doubled. Mean = 26.335227 ± .153066; mode = 26–27; σ = 3.010607 ± .108234.

Fig. 29. — *Aster prenanthoides* Muhl. Disk curve of 117 heads collected on September 27. Classes doubled. Mean = 56.427350 ± .248547; modes = 56–57, 60–61; σ = 3.985839 ± .175749.

Fig. 30. — *Aster prenanthoides* Muhl. Disk curve of 143 heads collected on September 30. Classes doubled. Mean = 51.713286 ± .281728; modes = 45–46, 51–52; σ = 4.994779 ± .199211.

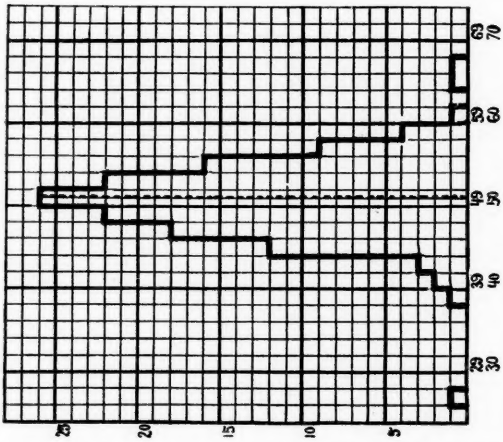

FIG. 31. — *Aster prenanthoides* Muhl. Disk curve of 139 heads collected on October 4. Classes doubled. Mean = 49.158273 ± .279452; mode = 49–50; σ = 4.884653 ± .197602.

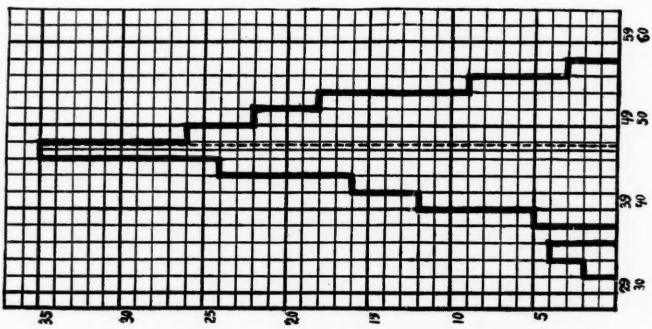

FIG. 32. — *Aster prenanthoides* Muhl. Disk curve of 176 heads collected on October 8. Classes doubled. Mean = 45.778409 ± .242280; mode = 45–46; σ = 4.777197 ± .171318.

	X_2	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
X_1		33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
-8	22			1																													
-7	23							2																									
-6	24	1					1	1	1																								
-5	25					1	2	2	1	1	2																						
-4	26					1				2	1	2	1				1																
-3	27								1	1			2	1								1											
-2	28											1	2	1	1			1						1									
-1	29									1		1		2	1																		
0	30													1	1	1		1	1														
0	31													1	2	1	4	3		1													
1	32															2	3	3			2												
2	33										1				1		2	4	2	1	2	1											
3	34														1		1	4	3	2	3		2		1				1				
4	35																		3		2	1											
5	36																			1		1	1					1					
6	37																						1										
7	38																				1	1						1					
8	39																																1
9	40																												1				

FIG. 33. — *Aster prenanthoides* Muhl. Correlation surface for 117 heads collected on September 27. Rays subject and bracts relative. $\rho = .855944 \pm .012237$.

	X_2	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9
X_1		32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
-11	17	1																						
-10	18																							
-9	19																							
-8	20																							
-7	21																							
-6	22	1	1		1		1	1	1															
-5	23				1		1	1	2															
-4	24			2		2				2	1	1	2											
-3	25	1						1	2	1				1										
-2	26						1		2	6	2	2	1	1	1									
-1	27										2	1	1	1										
0	28										2	1	3	4	3		2							
0	29										2		2	1	1		2	2		1				
1	30									1			1		3	2	3	3	1					
2	31													3	1	2	1	3	2	1	2		1	
3	32											1			1	1		1	2	3	1	2		1
4	33				1											1	1	2		5	4	1	1	1
5	34																2		2				1	
6	35																				1			
7	36																					1		

FIG. 34. — *Aster prenanthoides* Muhl. Correlation surface for 143 heads collected on September 30. Rays subject and bracts relative. $\rho = .833702 \pm .012701$.

	X_2	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11
X_1		30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
-8	20					1																					
-7	21							1		1	1																
-6	22							2																			
-5	23			2		1		2	1	2		1				1											
-4	24				1		1	2	1			1	3	1	1												
-3	25					2			2		4	1		1	1												
-2	26											1		2	1												
-1	27										1	2		3	5	2	1					1					
0	28								1				2	1	3	3	2	2	1		1						
0	29												1	1		2	2	2	1	2	2						
1	30														1	2	1		2		1	1					
2	31														1		1	2	2	1	1	2		1			1
3	32																2		2	2	2	4		2		1	
4	33																	1	1	2	1	5	1				
5	34																				1		1	1	1		
6	35																		1				1				
7	36	1																									

Fig. 35. — *Aster prenanthoides* Muhl. Correlation surface for 139 heads collected on October 4. Rays subject and bracts relative. $\rho = .798642 \pm .015133$.

	X_2	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12
X_1		29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
-7	19	1																									
-6	20									1	1																
-5	21	1	2	1			2																				
-4	22				2	2	2	1	2		4	1		1													
-3	23						2		2		1	1	1	2													
-2	24								1	2	1	4	4	2		2	1	1									
-1	25										2	3	4	2	1		1			2							
0	26										2	2	1	6	3	2	3	1									
0	27				1					1			4	5	3	6	5	5		1							
1	28													2	2	4	2	1	1	1		1					1
2	29													1		1		2	5	3	2	1					
3	30													1			1	1	2	1	4	4	1				
4	31																	1	1			3	2		1		
5	32									1													2				
6	33																	1				1					
7	34																					1					

Fig. 36. — *Aster prenanthoides* Muhl. Correlation surface for 176 heads collected on October 8. Rays subject and bracts relative. $\rho = .803092 \pm .013443$.

	X_2	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
X_1		42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
-8	22							1																										
-7	23													1				1																
-6	24					1								2		1																		
-5	25								1	2		1	1	2	1					1														
-4	26							1			2		1		1		1		1		1													
-3	27								1			1				2			1		1													
-2	28								1	1	1					1		1	1	1														
-1	29							1	1							1			1		1													
0	30									1			2	1					1															
0	31						1	2		1			2	2		1	1	1			1													
1	32										1	1	1		2	1	1	1	1	1														
2	33												3		1	3	1		1	2		2	1											
3	34	1									1		1		1	2	2	1		2	2	3	1			1								
4	35													1	1					2		1			1									
5	36																		1						1			2						
6	37																						1											
7	38																					1				1							1	
8	39																																	1
9	40																									1								

FIG. 37. — *Aster prenanthoides* Muhl. Correlation surface for 117 heads collected on September 27. Rays subject and disk florets relative. $\rho = .573693 \pm .033347$.

	X_2	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	0	1	2	3	4	5	6	7	8	9	10	11	12	13
X_1		35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
-11	17													1																		
-10	18																															
-9	19																															
-8	20																															
-7	21																															
-6	22														1			1	2	1	1											
-5	23												1		2		1				1											
-4	24									1		1	2		1	1	2		1	1												
-3	25												1	1				1	3													
-2	26								1			1	2		1		1		2	1	2	1	2	1			1					
-1	27									1							1			2	1			1								
0	28						2				2	1	1			1	1	2			2	2	1									
0	29	1													1	3	1	1	2				1	1								
1	30									2		1	1			1	2	2	2	1				1	1							
2	31						1						1		2			1	1	3	1	1	3		1		1					
3	32															1	2		1	1		1	2	2	1			1				1
4	33															1	2		2		1	2	1	2	1		2	1	1			1
5	34																1			1	2	1										
6	35																											1				
7	36																				1											

FIG. 38. — *Aster prenanthoides* Muhl. Correlation surface for 143 heads collected on September 30. Rays subject and disk florets relative. $\rho = .358909 \pm .042145$.

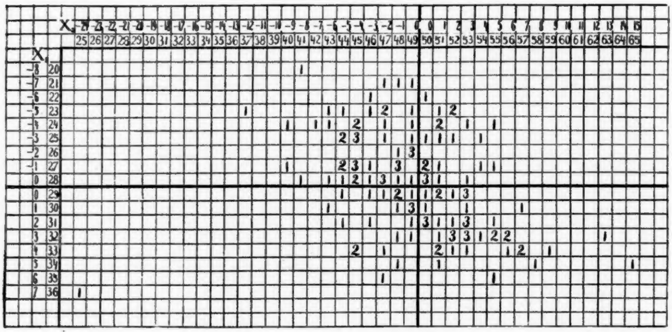

FIG. 39. — *Aster prenanthoides* Muhl. Correlation surface for 139 heads collected on October 4. Rays subject and disk florets relative. $\rho = .353102 \pm .043050$.

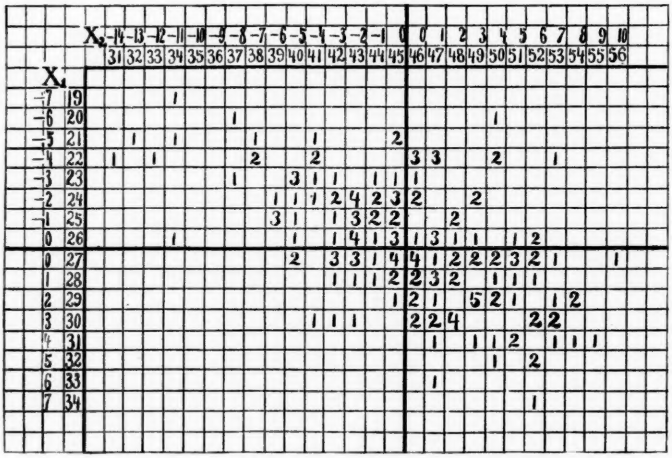

FIG. 40. — *Aster prenanthoides* Muhl. Correlation surface for 176 heads collected on October 8. Rays subject and disk florets relative. $\rho = .545208 \pm .012157$.

TABLE F. — CONSTANTS OF RAYS OF FOUR PICKINGS OF ASTER PRENANTHOIDES MUHL.

	117 CAPITULA, COLLECTED SEPTEMBER 27.	143 CAPITULA, COLLECTED SEPTEMBER 30.	139 CAPITULA, COLLECTED OCTOBER 4.	176 CAPITULA, COLLECTED OCTOBER 8.
Mean	30.769230	28.706293	28.251798	26.335227
Mode	26–27 32–35	30–33	24–25 28–29 32–33	26–27
A. D.	3.353057	2.991736	3.012680	2.452608
σ	3.985839	3.569141	3.501476	3.010607
P. E. A. D.	± 2.688448	± 2.407386	± 2.361745	± 2.030654
P. E. M.	± .248547	± .201316	± .200320	± .153066
P. E. σ	± .175749	± .142351	± .141641	± .108234
C. V.	12.953945	12.4333306	12.393818	11.431865

The variations of the disk in the four collections may be compared in the following table.

TABLE G. — CONSTANTS OF DISK FLORETS OF FOUR PICKINGS OF ASTER PRENANTHOIDES MUHL.

	117 CAPITULA, COLLECTED SEPTEMBER 27.	143 CAPITULA, COLLECTED SEPTEMBER 30.	139 CAPITULA, COLLECTED OCTOBER 4.	176 CAPITULA, COLLECTED OCTOBER 8.
Mean	56.427350	51.713286	49.158273	45.778409
Mode	56–57 60–61	45–46 51–52	49–50	45–46
A. D.	3.353057	3.925179	3.619481	3.750581
σ	3.985839	4.994779	4.884653	4.777197
P. E. A. D.	± 2.688448	± 3.368978	± 3.294698	± 3.222219
P. E. M.	± .248547	± .281728	± .279452	± .242280
P. E. σ	± .175749	± .199211	± .197602	± .171318
C. V.	12.953947	9.661212	9.936585	10.435481

4. *Correlations.* The correlation surfaces for rays and bracts, in the four collections, are shown in Figs. 33, 34, 35, and 36, and for rays and disks in Figs. 37, 38, 39, and 40. The coefficients of correlation are arranged for comparison in the following table.

TABLE H. — CORRELATION OF RAYS AND BRACTS AND OF RAYS AND DISK FLORETS IN FOUR PICKINGS OF ASTER PRENANTHOIDES MUHL.

		117 Capitula, collected September 27.	143 Capitula, collected September 30.	139 Capitula, collected October 4.	176 Capitula, collected October 8.
Rays and Bracts	ρ P. E. ρ	.855944 ± .012237	.833702 ± .012701	.798642 ± .015133	.803092 ± .013443
Rays and Disk	ρ P. E. ρ	.573693 ± .033347	.358909 ± .042145	.353102 ± .043050	.545208 ± .012157

Inspection of this table shows that the highest degree of correlation between the parts was found at the beginning of the flowering season, and that there was a constant fall for both bracts and disk florets until near the end of the season, when the coefficient of correlation again slightly increased. The increase in the coefficient of correlation between rays and bracts in the last collection was less than the "probable error" of the determination, but that between the rays and disk florets had increased until its value was only .0284 less than in the first collection.

V. DISCUSSION OF RESULTS.

The species which have been chosen for this study are quite distinct, and although *Aster puniceus* L. and *Aster prenanthoides* Muhl. belong to the same division of the genus, *Aster novæ-angliæ* L. is more distant from these, and *Aster shortii* Hook. belongs to a division which is separated in a marked degree from the others. Considering this wide separation, it is rather remarkable that there should be so close an agreement in the number of bracts in the four species. The lower limit of range varies from 28 to 30, the upper limit from 49 to 64, and the means from 36.8 to 44.5. With the bracts so nearly constant, there is a range in the mean number of rays from 14 in *A. shortii* Hook. to 42.8 in *A. novæ-angliæ* L., and yet the degree of correlation between rays and bracts is high in all

the species studied, the coefficient of correlation between them ranging from .549 + to .802 +.

The fact that the correlation between bracts and rays was found to be greater in every case than that between rays and disk florets gave rise to the question, What is the relation existing between bracts and rays? After a careful study of the position of the rays with reference to the bracts, it seems that the rays are axillary to the bracts, and that typically a nearly constant proportion of the bracts in the capitula of a species produce rays in their axils, the rest remaining empty. The material studied showed the mean number of empty bracts in each head to be as follows: *A. shortii* Hook. 22.8, *A. prenanthoides* Muhl. 16, *A. puniceus* L. 7.9, and *A. novæ-angliæ* L. 1.2.

The number of species here studied is too small to permit the derivation of laws covering so large a genus as Aster, but in these four species the degree of imbrication of the involucral bracts was apparently in direct proportion to the number of empty bracts. In *A. shortii* Hook., which has so many empty bracts, the scars left by their removal occupies the convex surface of an inverted cone, the base of which served as the receptacle for the comparatively small number of florets; while in *A. novæ-angliæ* L., where almost every bract has its ray, the scars formed a narrow ring about the broad receptacle. In the former there was considerable difference in form and size between the minute outer bracts and the inner ray-bearing bracts, while in the latter all the bracts were very much alike in size and form. In a number of capitula of *A. novæ-angliæ* L. there were found more rays than bracts. Some of the more marked cases of this kind were examined and the rays distinctly seen to form a scattering second row within the full outer row which is typical of Aster; in other words, some of the disk florets developed ligulate corollas.

The suggestion of several writers that statistical methods will prove valuable in taxonomic work is not sustained by the results set forth in this paper. It is obviously impossible to describe a species by means of the variability constants in such manner as to allow the classification of individuals which

possess but single variates of the kind used in determining those constants.

The above-stated results in *A. puniceus* L. make obvious the same truth in regard to species such as those of Compositæ, in which the individual may have a sufficient number of variates to give a good frequency polygon and constants with small "probable errors." The wide differences between the three individuals of *A. puniceus* L. show that the variability "constants" for individuals are only in a measure less variable than the characters upon which they depend.

The study of the successive collections shows another phase of the subject of variability which would materially affect the value of statistical methods in taxonomic questions relative to the Compositæ. In these successive collections there was a continuous decline in the numbers of bracts, rays, and disk florets, and a continuous change in the position of means and modes. These results could have been in no way dependent upon unnatural conditions induced by the clipping of the heads, since even the last to bloom were well-developed buds at the time the first collection was made; and had there been a change brought about in this way, it must have been in the opposite direction, since it is a well-known fact that the removal of the earlier flowers gives increased vigor to later ones.

This continuous change of means and modes during the blooming season is suggested as a possible explanation of Lucas's (**'98**) results upon *Chrysanthemum leucanthemum* L., other than that of difference of locality. He found that there was a marked difference between the results obtained from material collected at Yarmouth and Grand Pic, Nova Scotia, and that collected later at Milton and Cambridge, Mass. The earlier material from Nova Scotia showed the mean on 24.389 and the principal mode on 22, while the later collection from Massachusetts had the mean on 21.61 and the mode on 21.

Ludwig (**'00**), in commenting on these results, attributes their deviation from his own observations to the scantiness of Lucas's material, while Lucas implies, though he does not say it definitely, that the difference is a local one. In the light of my observations on *A. prenanthoides* Muhl. it seems a fair

question whether the difference may not have been in part due to the difference in the time at which the collections were made.[1]

Although the material of *A. prenanthoides* Muhl., upon which this study of successive collections is based, is even less than that used by Lucas, the constancy of the fall in numbers of all the parts can leave little doubt as to the essential correctness of my results. As a few days makes a marked difference in the condition of these variable characters, different seasons may likewise be found to give different results upon material collected from the same individuals.

As the capitula which terminate the axes in the Asters are the first to bloom, my observations on the decline in the number of parts in the heads of *A. prenanthoides* Muhl. bear a close relation to those of Burkill ('95) on *Caltha palustris* L., *Ranunculus arvensis* L., *R. bulbosus* L., *R. Ficaria*, and *Thalictrum flavum*, where he arrives at the conclusion that the "position of the flower on the axis affects the sexual organs, if they vary." [2]

Ludwig ('00) remarks concerning this, that "weil die Zahl der Carpelle, ebenso wie die der anderen Blütentheile und der Blütenzahlen in der Inflorescenz von der Stellung an der Axe abhängig ist, wird man Mischcurven erhalten, wenn man die Zählungen auf sämmtliche Organe der einzelnen Pflanze, nicht auf einzelne gleichwerthige Organe der verschiedenen Pflanzen

[1] Since this was written, W. L. Tower has investigated *Chrysanthemum leucanthemum* L. with reference to this point, and found that there is a continuous decrease in the values of mean and modes from the beginning to the end of the flowering season. His results will appear in *Biometrika*, vol. 1, no. 2.

[2] In his studies on the plants named, and others in which the number of stamens and carpels vary, he finds that "the earlier formed flowers on the plant carry more stamens or more carpels, or perhaps more of both organs, than those formed later in the season," and that "flowers holding any position of advantage on an inflorescence, *i.e.*, terminal on a cyme, or at the base of a raceme, even if not maturing earliest, carry more stamens or carpels or more of both, than in the other flowers of the same inflorescence."

Finally, he finds that in forms such as *Stellaria media*, and *Ranunculus ficaria*, which have a long flowering season, there is a noticeable decrease in the number of stamens and carpels during the flowering season, regardless of their location on the inflorescence, — a result which is closely paralleled by my work on *Aster prenanthoides* Muhl.

ausdehnt, und zur Bestimmung der constanten Mischcurve der Art ist eine sehr grosse Anzahl von Zählungen nöthig."

I agree with Ludwig that a large number of counts is necessary for the determination of the constants in material of this kind; but how great must it be? It is to be noted that, in his tables representing the variation in number of achenes in the heads of *Ranunculus acris* L., he gives the results of two sets of observations, each consisting of counts of 1000 heads. The maxima of the two multimodal curves formed, alternate with each other, and their summation gives but few maxima where they ought (?) to be, — the material is insufficient; yet he makes virtue of the fact that the summation of Lucas's data, only 831 counts, presents maxima upon the series of Fibonacci.

This series of Fibonacci, which is of recognized importance in the phyllotaxy of flowering plants, should be accepted with caution as the key to all variation among plants. The members of the series, along with Ludwig's "Unterzahlen," which are made up from the numbers of the Fibonacci series by multiplication or addition, — *e.g.*, $10 = (2 \times 5)$, $29 = (8 + 21)$, etc., — include so large a proportion of all the smaller numbers that many modes must fall on or near one of them, even if there be no fundamental relation existing between this complex series and the number of floral parts or other organs under consideration. To account for modes which do not fall on any of these, Ludwig creates the "Scheingipfel," which is formed by the overlapping of curves having their modes on adjacent numbers of the Fibonacci-Ludwig complex. Thus, if the maximum falls upon 9, it is a "Scheingipfel" formed by the union of curves having maxima upon 8 and 10; if it fall upon 11, it is made up of curves having maxima upon 10 and 13, etc. It is evident that such a scheme will furnish an explanation of almost any condition which might arise.

In conclusion, it needs to be said that there remains much to be done in determining the many causes of variation. The quantitative study of variation shows only the existing condition of the material studied. It deals only with results, and if there has been no intentional selection of material, it indicates nothing as to the causes which have brought about those results.

While deprecating the selection of material on false bases, I take it that intelligent selection of material existing under known conditions is more certain to give valuable results than at-random selection, which, while sure to select, ignores the conditions under which the selection is made.

Until we know the causes of variation and how great degree of variation may be produced by how slight causes, all generalizations based upon limited observations should be accepted with caution. Granting that observers have no preconceived notions as to what they ought to find, the conditions found by each investigator are true of the material upon which he worked, but how true his general conclusions are, further investigation alone can tell.

If every valley and hillside is to have its own place-mode and every day and every season is to bring forth a changed condition in the variable characters of its living forms, only a universal collection of material covering a long period of years can give us true constants which may be verified by a repetition of the process.

VI. Summary.

Quantitative studies were made upon the bracts, rays, and disk florets of four species of Aster growing at Yellow Springs, Ohio.

A close correlation was found between bracts and rays, and attributed to the fact that the rays are axillary to the bracts.

The degree of imbrication of the bracts was observed to bear a relation to the number of empty bracts.

Curves and "constants" were determined for the material of the four species studied. "Constants" determined for several individuals of *A. puniceus* L. growing in identical surroundings indicated how great variations may exist in the variability "constants" of individuals.

Studies upon successive collections from a single group of specimens of *A. prenanthoides* Muhl. showed that the number of bracts, rays, and disk florets all decrease continuously from the beginning to the end of the flowering season, and that the

character of the curves and the position of their means and modes likewise change continuously.

I wish to express my thanks to Prof. W. L. Tower for his kindly interest and helpful suggestion during the prosecution of these studies, and also for the revision of the manuscript.

YELLOW SPRINGS, OHIO.
June 25, 1901.

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EDITORIAL COMMENT.

In order that our summaries may correspond, so far as possible, to the calendar year, "The Quarterly Records of Gifts, Appointments, Retirements, and Deaths" will hereafter appear in the numbers for February, May, August, and November. Under the heading "Educational Gifts" we have included all donations from private individuals for distinctively educational purposes, so far as they have come to our notice. We have included, therefore, not only gifts to schools and colleges, but those to libraries and museums, since in many cases it is otherwise impossible to draw a sharp line. We have not included in our summaries appropriations by the national, state, or local governments for educational purposes, nor have we included the formal transfer by Mrs. Stanford to the Leland Stanford Junior University of securities and other property, with an estimated value of $30,000,000, the largest single gift for educational purposes in the history of the world. Yet, omitting these, the gifts for the year 1901, as catalogued in our pages, foot up the enormous sum of $43,233,635. These recent educational gifts, increasing in amount as the years go by, are of immense importance in any estimate of the future of education in America, and in the opinions of some are not an unmixed blessing. Certainly, so far as the financial basis is concerned, the United States will soon stand ahead of any country in the world, but the question cannot help suggesting itself, Will it advance as rapidly and to such prominence in intellectual matters as it does in the material side of education?

While speaking of our Record it may not be out of place to say that since the *American Naturalist* came into the hands of the present management its notices of appointments, resignations, and deaths has been the most complete published. In these years 1717 personal notes have appeared under these three headings.

NOTES AND LITERATURE.

GENERAL BIOLOGY.

Mechanism and Vitalism. — Under the title of *Mechanismus und Vitalismus*, Prof. O. Bütschli has published in brochure form his address before the International Zoölogical Congress which met in the summer of 1901 in Berlin. Bütschli points out that the modern thinkers and investigators who stand for the doctrine of vitalism, and who are often referred to as "Neovitalists," do not in reality uphold anything fundamentally new, since there is no important distinction between the old and the new vitalism. Both the old and the new doctrine rest on the assumption that life and life-processes cannot be understood, or at least not entirely understood, except as the outcome of a special principle, or force, or of a "peculiar something," which is not present in inorganic or rather dead substances. The new doctrine of vitalism goes further, perhaps, in maintaining that the purely causal mechanical point of view of living phenomena is also as correct as the teleological, but even this is not a real departure from the older view, since the latter also expressed itself causally in the sense that the postulated vital force, that was supposed to account for the phenomena of life, acted according to the causal formula.

Bütschli begins by defining as briefly as possible his own general standpoint in regard to the theory of knowledge. A few pages are given up to the discussion of the *Ego* and the *Object*. It is not clear why the author should introduce his subject by such a thread-worn metaphysical discussion, which is likely, in our opinion, to discourage and disappoint the reader at the start, but the mantle of metaphysics falls on the seventh page, and the author returns to his real theme.

Bütschli states that by "mechanism," as applied to the organism, he does not mean simply the kind of mechanics that deals with motion and with equilibrium, but rather the conception of the organism on the bases of regular sequence of cause and effect in the same way in which we account for inorganic changes. "A purely mechanical conception is impracticable even in inorganic phenomena."

There follows an explanation of that most evasive of German words, "Auslösung," and its relation to causal phenomena. Bütschli then

proceeds to give a neat and convincing account of what is meant by a "descriptive" science and points out how a number of modern critics have misinterpreted the term. In their desire to show that all science is only descriptive they have failed to discriminate between orderly sequences, such as night following day, and necessary sequences, such as the explanation of the alternation of night and day as the outcome of the revolution of the earth on its axis, etc.

After discussing whether the simplest organisms — bacteria for instance — might be accounted for as the outcome of a physico-chemical accident, Bütschli asks: If this is possible, can the same assumption account for the highly complicated organism? This leads to a discussion of what is meant by "chance" or "accident." Bütschli points out that one of the chief peculiarities of living things is their power of reproducing other living things like themselves, so that if a given form once arose by chance, its continuation does not any longer depend on chance, since by its own nature it reproduces that special group of "accidents" that brought it into existence. The argument leads naturally enough to Darwin's hypothesis of the origin and survival of chance variations. Bütschli affirms his belief that up to the present no better hypothesis has been advanced to explain the adaptation of organisms to their environment. There follows an admirably clear analysis of what we mean by adaptation. It would lead too far to enter into this discussion, but we cannot refrain from expressing great admiration for the clearness and ability with which the subject is handled.

Pflüger's "teleological causal law" is skillfully divested of its metaphysical covering. Bütschli points out that the same law is equally applicable to a steam engine with a regulator. Cossmann's recent argument, in which he attempts to demonstrate a special "biological" sequence of causes and effects in organisms as contrasted with the sequence in the inorganic world, is severely criticised and its fallacy exposed.

Bütschli points out that Driesch's demonstration of vitalism rests on a very doubtful assumption. If it could be shown, as Driesch claims, that the reorganization of a piece of an egg or of an adult into a new whole with proportionate parts is a phenomenon peculiar to living things, then Bütschli admits that Driesch might make good his position, but that this is true is by no means proven to be the case. As a parallel inorganic phenomenon it is pointed out that a drop divided in two forms two new drops. Again, if a drop of some

substances is drawn out into a cylindrical thread, the latter will, under certain conditions, break up into a series of drops of definite size and of definite distances from each other. If two such cylindrical threads of unequal size are treated in the same way, they will form drops proportionate to the original sizes of the threads, etc. Here Bütschli claims we find an analogy to the tripartite division of the archenteron of the gastrula of the sea urchin. I may add that a still more striking parallel is to be found in the behavior of the "fluid crystals" described by Lehmann. If a portion of one of these is pinched off, it shows from its optical behavior that it has assumed the crystal condition characteristic of the original whole.

Bütschli concludes: The old and the new vitalism alike emphasize the presence of the unsolved riddles of biology and express a doubt as to their solution on mechanical principles. They teach us nothing about the organism, since the very premises of the vitalistic argument rest on the assumption of an ultimate orderly action that is in itself beyond our comprehension. Therefore, we may well say that we can only grasp those parts of the phenomena of life that we can interpret by means of physico-chemical principles. T. H. M.

Biometrika, "a journal for the statistical study of biological problems," makes its first appearance with the number for October, 1901. Its aim is to serve "as a means of collecting under one title biological data of a kind not systematically collected or published in any other periodical," and of spreading such a knowledge of statistical theory as may be requisite for scientific treatment of the data collected. The editors are "in consultation with Francis Galton," Professors W. F. R. Weldon, Karl Pearson, and C. B. Davenport. *Biometrika* is published in Cambridge, England, at the University Press, a sufficient guarantee that the excellent form given to the initial number will be maintained. An excellent portrait of Darwin, from the Pinker statue at Oxford, forms the frontispiece. An editorial by Francis Galton is followed by papers by Professor F. Ludwig, Miss M. Beeton, and Professors Karl Pearson, W. F. R. Weldon, and other well-known students of variation.

ZOÖLOGY.

Biogeographical Regions. — A valuable contribution to biogeography has recently been published by Jacobi.[1] The author has accepted the modern views on geographical distribution, and especially the fundamental idea that the present distribution does not correspond, in many cases, to the present conditions of life, but has often its origin in the past, and indicates conditions prevailing in former geological periods. He points out that the best zoögeographical divisions proposed by previous authors have not covered all cases, and cannot do so, because the past conditions were often directly the opposite to the present ones. Nevertheless, he tries to give a scheme that is intended to unite past and present conditions,[2] and selects Lydekker's division in three realms (Arktogæa, Neogæa, and Notogæa) as the most appropriate, since he believes that it *accounts best for the distribution of mammals and birds from the beginning of Tertiary times.*

Aside from the question whether it is necessary at all to have any biogeographical realms or regions, we cannot agree with this idea that biogeography ought to unite past and present conditions into *one* scheme; indeed, in many cases it is directly impossible to do so, since we do not see any way to reconcile connection and disconnection. And in most cases it would amount just to this, to bring under one head certain parts of the earth's surface which are now connected, while they were formerly disconnected, — or *vice versa.* Believing this to be an impossible task, we have always advocated another method of investigation, namely, the attempt to establish the present conditions of life (not the actual distribution of animals or plants) and to divide the earth into regions accordingly. These regions refer only to the *present* time, and by comparing this scheme with the actual distribution of animals, those cases which do not agree with it are at once revealed. This method calls our attention to those facts in distribution which need special investigation and explanation, and in most cases we shall be able to account for them

[1] Jacobi, A. Lage und Form biogeographischer Gebiete, *Zeitschrift der Gesellschaft für Erdkunde zu Berlin,* Bd. xxxv, Heft 3 (1900), pp. 147–238. 2 pls.

[2] The same idea has been advocated by Prof. H. F. Osborn (*Science,* April 13, 1900, p. 563), who says: "This, then, is our problem, to connect living distribution with distribution in past time and to propose a system which will be in harmony with both sets of facts."

by supposed changes in the conditions of life that have taken place during the earth's history.

The investigation of instances of the latter kind forms a large part in Jacobi's paper, and he has collected valuable material which tends to show that certain parts of the earth's surface, in their fauna and flora, possess a uniformity which is inexplicable by the present conditions. He calls those parts "areas of dispersal" (*Ausbreitungsgebiete*) and indicates them on his map (Pl. VII). There are fifteen of them :

1. Greenlandian.	6. Arabian.	11. Philippinian.
2. Lusitanian.	7. Indo-African.	12. Southern Japanese.
3. Mediterranean.	8. Antarctic.	13. Siberian.
4. Sarmatian.	9. Papuan.	14. Beringian.
5. Iranian.	10. Farther Indian.	15. Central-American.

Of these, the 4th (southern Russia and Turkestan), the 5th (Persia), the 10th (Farther India), and the 15th (Central America) are situated on continents and do not present any remarkable features, since they are not opposed to the present conditions.

The 2d, connecting England with western France and Spain, the 3d, connecting the Mediterranean countries, the 9th, connecting New Guinea with Australia, the 11th, connecting the Philippine Islands with each other and with Formosa, the 12th, connecting South Japan with Korea and China, the 13th, connecting North Japan with Siberia, and the 14th, connecting Siberia and Alaska, are well known and have been generally accepted as well established.

The chief interest centers in the remaining areas of dispersal, namely, the 1st (connection of East Greenland with Spitzbergen, Norway, and Scotland), the 6th and 7th (connection of East Africa and India, partly by way of Abyssinia and Arabia, partly by way of Madagascar and the islands of the Indian Ocean), and the 8th (connection of South Africa, Australia, New Zealand, and South America with Antarctica). Indeed, none of these connections is new to science, and some of them have been repeatedly discussed lately, but it is interesting that Jacobi's studies have led him also to the assumption of the former existence of these very important biogeographical relations, which can only be explained by the theory of a former connection of the respective parts by land. In the demonstration that such conditions must have existed in former times, and in the collection of known facts as well as introduction of new ones, which tend to support this assumption, lies the chief value of

this paper, and thus it will be of great use to any one who proposes to study these highly interesting zoögeographical questions.

A. E. O.

The Apogonoid Fishes of Japan. — Jordan and Snyder continue their monographic reviews of the various groups of Japanese fishes with an account of the cardinal fishes, or Apogonidæ. Seventeen species are described, most of them being figured. Six of these are new, one new genus, Telescopias, being recognized. The authors have overlooked the fact that Dr. Günther has substituted the generic name of Synagrops for Melanostoma, which is preoccupied. D. S. J.

Jenkins on Hawaiian Fishes. — In the *Bulletin of the United States Fish Commission*, Dr. O. P. Jenkins continues his studies of the very rich collection of Hawaiian fishes made by him in the summer of 1889. Fifteen species are described and figured as new: *Sphyræna helleri, Sphyræna snodgrassi, Anthias fuscipinnis, Aphareus flavivultus, Eupomacentrus marginatus, Chromis velox, Chætodon mantelliger, Chætodon sphenospilus, Ostracion camurum, Ovoides latifrons, Tropidichthys jactator, Eumycterias bitæniatus, Scorpænopsis cacopsis, Parapercis notostigma, Brotula marginalis.* Later investigations of the Hawaiian Commission, of which Dr. Jenkins is a member, show that *Chætodon mantelliger* is the original *Chætodon miliaris* of Quoy and Gaimard; *Parapercis notostigma* has been recently and earlier described as *Percis schauinslandi* by Steindachner.

D. S. J.

Seale on Hawaiian Fishes. — In an "Occasional Paper of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History," Mr. Alvin Seale, curator of ichthyology, describes six new species of fishes from Honolulu, illustrating them with photographs of the type specimens.

These species are: *Epinephelus quernus, Novaculichthys tattoo, Serranus brighami, Balistes fuscolineatus, Monocanthus albopunctatus, Thalassoma berndti* (misprinted "berendto").

Of these the *Serranus brighami* seems to be related rather to Etelis than to Serranus.

D. S. J.

Starks on the Synonymy of the Fish Skeleton. — In the *Proceedings of the Washington Academy of Sciences*, Mr. Edwin Chapin Starks gives a comparative study of the names applied to the bones of fishes. This will prove a great convenience to students

of osteology, as giving a clue to the labyrinth of names due to the premature assumption of homologies between the fish skeleton and that of man.

There are now few fields in zoölogy so little worked and at the same time so repaying as that of the comparative osteology of the bony fishes. Most anatomists treat the group as though all bony fishes were alike in their osteology.

The paper is illustrated by plates of the skeleton of the "Striped Bass," the best drawing of the fish skeleton yet published. These are by Mrs. Chloe Lesley Starks.

D. S. J.

Eigenmann on a New Psenes from Newport, Rhode Island. — In the *Bulletin of the United States Fish Commission*, Dr. C. H. Eigenmann describes a new oceanic fish from the Gulf Stream off Newport, under the name of *Psenes edwardsi*. It was found, as is often the case with other nomeid fishes, under a Portuguese man of war. The diagnosis of the family Nomeidæ is amended by Dr. Eigenmann. The group possesses, like the Stromateidæ, denticles in the throat, and, according to Eigenmann, it differs only in the larger number of the vertebræ. But in Stromateidæ, as in Nomeidæ, the vertebræ are in increased numbers, 30 to 36. I know at present no real difference between the two families.

D. S. J.

Eigenmann on the History of the Young Squeteague. — In the *Bulletin of the United States Fish Commission*, Dr. Eigenmann gives a useful study of the development of the young weakfish, or squeteague, *Cynoscion regalis*.

D. S. J.

Nishikawa on the Development of the Japanese Anchovy. — In the *Journal of the Japanese Fisheries Bureau*, Mr. T. Nishikawa gives a similar study of the development stages of the common anchovy of Japan, *Engraulis japonicus* Schlegel. By some error, Mr. Nishikawa accredits the name *japonicus* to Houttuyn. Houttuyn's *Atherina japonica*, however, was not an anchovy but a sardine.

D. S. J.

Boulenger on the Classification of the Trachinoid Fishes. — In the *Annals and Magazine of Natural History*, Dr. G. A. Boulenger has a very valuable study of the osteology and relationships of the group of fishes called Trachinoidea.

The family of Trachinidæ was established by Dr. Günther in 1861, for spiny-rayed fishes, with perfect ventrals, short first dorsal, and lacking the special traits of other related groups.

The family was evidently a provisional one, and several writers, notably Dr. Gill and Dr. Bleeker, have noted the incongruity of its members and suggested the removal of certain of its subdivisions to other groups. Nevertheless, in default of any study of the skeletons, these families have been kept in some sort of association by subsequent writers. The study of the skeletons shows plainly the necessity of a complete revision of the assemblage. This has been done by Dr. Boulenger.

Dr. Boulenger shows first that in Trachinus the scapular fenestra, as in the codfishes, lies between the scapula (hypercoracoid) and the coracoid (hypocoracoid) instead of piercing the former, as in ordinary fishes. This character is shared by Notothenia, Chænichthys, Parapercis, Eleginops, Harpagifer, Trichonotus, Callionymus, and their relatives. All these lack the supraocular lamina, which is present in Trachinus. Trichonotus and Callionymus show other osteological characters, which separate them as families, although not invalidating their general trachinoid relationship. The genus Percophis agrees closely in osteology with Trachinus, but the scapular fenestra is entirely within the scapula as in the percoid fishes.

Bembrops, Chimarrhichthys, and Leptoscopus agree with Notothenia in the absence of a subocular lamina, but differ in having the fenestra within the scapula. These forms show affinities with the Batrachoididæ. Boulenger refers them to Leptoscopidæ.

Dactyloscopus, which has reduced ventrals and the pectoral arch of Clinus, is regarded as a true blenny, notwithstanding its apparent likeness to Uranoscopus. Gillellus, Dactylagnus, and Myxodagnus will doubtless go with it.

Uranoscopus and its allies (Anema, Ichthyscopus, Kathetostoma, Ariscopus) have also the scapular fenestra in the scapula, but show a number of other osteological peculiarities. They are, however, unquestionably trachinoid in general relationship.

The group Trachinoidea in Boulenger's view, therefore, includes the following families : Trachinidæ, Nototheniidæ, Percophidæ, Leptoscopidæ, Uranoscopidæ, Trichonotidæ, and Callionymidæ. All these agree with the Blenniidæ, Batrachoididæ, Ophidiidæ, and Gadidæ in having jugular ventrals, in which the fin rays are frequently not of the normal number which is I, 5. For the division or suborder of fishes thus characterized, containing these families and their allies, Dr. Boulenger proposes to revive the old name "Jugulares."

The remaining genera referred to Trachinidæ or to Trachinoidea show no real affinity with Trachinus, Callionymus, and Uranoscopus.

They have not jugular ventrals and should be removed to other parts of the system.

The Chiasmodontidæ (including Chiasmodon, Pseudoscopelus, and apparently Champsodon) have the ventrals rather abdominal than thoracic, not being connected with the pectoral arch, or in Champsodon joined by ligament only. These may be Percesoces, but that is very unlikely and their real affinities are doubtful.

The Trichodontidæ (Trichodon and Arctoscopus) are percoids, most nearly related to the Latrididæ.

The Sillaginidæ are, as supposed by Cavier, most nearly allied to the Sciænidæ.

Most of the remaining genera agree closely in skeletal characters, notwithstanding their variations in external appearance, and their actual relationships are altogether percoid, approaching closely to the genus Plesiops, which Boulenger ranges among the Serranidæ of the Anthias group. These constitute the family Pseudochromididæ, composed of Pseudochromis, Cichlops, Opistognathus, Latilus, Caulolatilus, Malacanthus, Bathymaster, and their allies. This family seems to the writer still very heterogeneous. Bathymaster has a greatly increased number of vertebræ, Pseudochromis has two lateral lines, and Opisthognathus differs superficially in many ways from Latilus. Cepola, not mentioned by Boulenger, must lie near this group as a distinct family, Cepolidæ. Pinguipes differs from all this in lacking the supraocular lamina. It forms a distinct family, Pinguipedidæ.

D. S. J.

Jordan on Distribution of Fishes. — In *Science*, Dr. Jordan has an extended account of the origin of the fish fauna of Japan, with deductions of general application from the relation of the Japanese fauna to those of other regions.

He finds no evidence from the fishes of a direct connection between Japan and the Mediterranean, and no evidence of the submergence of the Isthmus of Suez. In the large identity of genera, and the divergence of species on the two sides of the Isthmus of Panama, he finds evidence of former submergence (perhaps Miocene) but none during the lifetime of the present species. He does not find in the wide distribution of the Antarctic fresh-water troutlike genus, Galaxias, certain evidence of the former union of South America and Australia in Antarctic Continent, but would accept the theory on geological evidence.

In a note in a subsequent number of *Science*, Dr. A. E. Ortmann claims the existence of adequate geological evidence of the former extension of the continent "Antarctica." In this case the distribution of Galaxias would be easily explained, but it could be conceivably explained without it. Dr. Ortmann notes also evidence of the faunal union of Japan with Europe when the climate of Siberia was much warmer than now. This evidence is drawn from the distribution of Crustacea. The distribution of the fishes does not, however, yield evidence of this kind.

D. S. J.

Jordan and Snyder on the Puffing Fishes of Japan. — In the *Proceedings of the United States National Museum*, Jordan and Snyder continue their monographic reviews of the fishes of Japan, treating of the gymnodont fishes, or puffers. Twenty-seven species are described, belonging to eight genera. Four new species are figured, besides several previously known. The authors unite the genus Lagocephalus with Spheroides, finding a continuous series from one extreme to the other. In like manner, Ovoides is merged into Tetraodon.

D. S. J.

Kerr on the Paired Limbs of Vertebrates. — In the *Proceedings of the Cambridge Philosophical Society*, Mr. Kerr discusses the question of the origin of the paired limbs in vertebrates. He finds the view of Balfour and others, that these limbs had their origin in a lateral fold, without adequate support in fact or in theoretical considerations.

The view of Gegenbaur, that they arose from modification of the gill septa separating gill slits, he also criticises unfavorably.

As a provisional hypothesis he brings forward the theory, already foreshadowed by others, that the vertebrate limbs are modified external gills. The close association of the fore limbs and gills shown in Mr. Kerr's plates of the young Lepidosiren, in another paper, seems to lend color to this theory.

D. S. J.

Notes on Fishes. — Professor Alfredo Dugès of Guanajuato has recently sent a bottle of little fishes taken in the very hot spring at Ixtlan, in the northwestern part of the Mexican state of Michoacan. These belong to the species described by Woolman as *Gambusia infans*. It is a valid species, distinguished by its small size and plain color among other things, but the original description is at fault in

placing the beginning of the dorsal opposite that of the anal. As usual in this group, the dorsal is considerably beyond the front of the anal fin. D. S. J.

In the *American Naturalist* for March, 1901, I published a note in regard to the planting of fish in Crater Lake, Oregon, in the summer of 1900, by the Rev. Edwin Sidney Williams of Saratoga, Cal., who was of the opinion that fish had not previously existed in the lake.

Mr. J. S. Diller of the United States Geological Survey has recently informed me that he visited the lake in July last and saw in it a number of fish, ranging in size from six to thirty inches, the largest ones in many cases being white upon the back or other parts of the body as if diseased, and on this account being readily seen. The smaller ones were in good condition. The fish were spotted like the large trout of the Klamath Lake region. None of them were captured. Mr. Diller had no difficulty in getting them to take grasshoppers or white pumice when thrown into the water.

From the large size of some of these fishes it would appear that they existed in the lake prior to Mr. Williams's visit. They were doubtless results of some earlier plant from the Klamath.

D. S. J.

About March 10, 1897, the State Fish Commission of California, through Mr. Norman B. Schofield, assistant, planted 855,000 young fry of the quinnat salmon in Paper Mill Creek, the chief tributary of Tomales Bay.

As this stream has never contained any salmon, and is open to observation for its length of twenty-five miles, this operation gave especially good opportunities for the observation of the young fish.

They soon dropped down from the stream in which they were planted, tail first, salmon fashion, and in forty-five days were found in considerable numbers in brackish water. Some of the young salmon were taken in April at Marshall, fifteen miles down the bay. In June they disappeared entirely.

The next year, 1898, two million additional salmon fry were placed in Paper Mill Creek.

Recently, about Nov. 1, 1901, four and a half years after the first planting, an adult male quinnat salmon weighing about seventeen pounds was sent to me from Mr. A. D. Hochfort of Point Reyes, as one of a large run of strange fish seen for the first time in Paper Mill Creek. D. S. J.

BOTANY.

Chamberlain's "Methods in Plant Histology."[1] — The thin volume at hand is based on a series of elementary articles in the *Journal of Applied Microscopy* dealing with methods of studying the finer structure of plants. It is, therefore, a discussion of methods rather than a treatise on plant histology. Chapters dealing with reagents, methods of killing and fixing, staining, sectioning, and mounting deal with the processes named. The directions are given in a clear, straightforward style, and numerical data appear where most desirable. The preparation of reagents is described fully enough, and the absence of citations of indefinite quantities and time limits, which often renders useful books less useful than they might be, is commendable.

The second part deals with the most useful methods of preparing material, from the lowest to the highest groups of plants, and special methods and devices for difficult types of plant life are described. Some of the main features to be looked for are indicated, mainly as a means of judging of the success of the preparation.

Although in no sense a complete work, one rendering Lee's *Vade Mecum* or Zimmermann's *Microtechnique* less necessary, most teachers of botany not themselves primarily histologists will find this volume a very useful addition to their shelf of ready reference books.

R. H. T.

Notes. — Very substantial evidence of activity in the botanical laboratory of the Imperial University of Tokyo, Japan, under the direction of Dr. M. Miyoshi, professor of botany, is at hand in the shape of several papers published in the *Journal of the College of Science* during the current year.

K. Saito[2] presents an anatomical study of the most important plant fibers of Japan, giving attention especially to those derived from bast cells. The shape, dimensions, markings, contents, and wall structure are indicated, and the reactions of the walls to the most important reagents stated. Several points of interest bearing on the developmental history of certain of these fibers have been

[1] Chamberlain, Charles J. *Methods in Plant Histology.* Chicago, University of Chicago Press, 1901. 159 pp.

[2] Saito, K. Anatomische Studien über wichtige Faserpflanzen Japans mit besonderer Berücksichtigung der Bastzellen. *Journ. Coll. of Sci., Imp. Univ. Tokyo,* vol. xv, pt. iii (1901), pp. 395–462. 2 pls.

worked out. The work closes with a key for the microscopical identification of the fibers of Japan.

S. Kusano[1] reports investigations made to determine the amount of transpiration taking place in evergreen trees of Japan in winter. He finds that the giving off of water from the foliage at no time actually ceases, even though the minimum temperature (in Hondo) falls to a point several degrees below zero. The time of least transpiration is, however, found to coincide with this minimum, falling in the month of January. Since photosynthetic activity has been shown by Miyake not to come to a complete standstill in winter in the latitude concerned, Kusano concludes that the abundance of evergreen trees in Japan is chiefly due to its favorable climate.

H. Hattori[2] has studied the action of copper sulphate on certain plants during considerable periods and agrees with those who have previously investigated the effects produced by copper salts in finding that it is extremely toxic in its action. Amputated conifer twigs, seedlings, pot plants, and molds were used in his experiments. Little that is entirely new has been developed, but a number of interesting things are reported. Among others is the fact that copper sulphate in a solution containing 0,000,001 per cent of the salt is not harmful to corn seedlings cultivated in it for considerable periods. The capacity of the soil for fixing considerable quantities of salt supplied to it in solution accounts for the greater amount of copper endured by plants grown in pots of earth. Molds grown in copper containing culture media were found to be stimulated by minimal amounts of the metal, 0,004 per cent to 0,008 per cent being indicated for Aspergillus and Penicillium, respectively.

T. Inui[3] has studied the lower plant organisms connected with the preparation of awamori, an alcoholic, whisky-like beverage brewed in the Luchu Islands (situated between Formosa and the Kiushu Islands).

Boiled rice or millet is inoculated from material of former cultures and, after sufficient growth has been made first on the grain in a

[1] Kusano, S. Transpiration of Evergreen Trees in Winter, *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1901), pp. 313–366. 1 pl.

[2] Hattori, H. Studien über die Einwirkung des Kupfersulfats auf einige Pflanzen, *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1901), pp. 371–394. 1 pl.

[3] Inui, T. Untersuchungen über die niederen Organismen welche sich bei der Zubereitung des alkoholischen Getrankes "Awamori" betheiligen, *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1891), pp. 465–478. 1 pl.

moist atmosphere and afterwards in a more watery preparation, the alcoholic product is obtained by distillation. The author has isolated several new forms from the material used, — *Aspergillus luchuensis*, related to *Aspergillus wentii* Wehmer; *Aspergillus perniciosus*, near the latter; and *Saccharomyces awamori*. He reports the presence of a species of Monilia and of *Saccharomyces anomalus*, which latter form produces the characteristic aroma.

Professor Miyoshi[1] makes a second contribution to his study of a mulberry disease called "Ishikubyo," and comes to most interesting conclusions. The injury is due to a lack of proper balance in the tissue development of the plant. The leaves manufacture more carbohydrates than the conducting system is able to withdraw during the usual time. The woody tissue of affected plants in all parts is also underdeveloped, and a diminished water transpiration results. This account is the more interesting since physiological derangements are not often traced back to ill-balanced tissue formations.

In this connection it may be noted that Suzuki, investigating this disease in the light of Woods's work on the "mosaic disease" of the tobacco plant, has come to the conclusion that in the mulberry, as in the tobacco, the trouble is due to an overproduction of oxydizing enzymes accompanied by a more or less advanced state of starvation.

Another article by Professor Miyoshi[2] reveals an extremely perfect means for securing spore dissemination in a new tree-inhabiting Japanese lichen named by the author *Sagedia macrospora*. The rounded sporocarps lie imbedded in the thallus until ripe, when, through the weakening of the tissues surrounding them, they separate from the thallus as free rounded masses. On absorbing water, the sporocarp expands and opens out by means of the hygroscopic properties of the walls, exposing the hymenium. The spore-containing sacs rupture, thus freeing the spores. The fixation of the free sporocarp to the bark of the tree is secured by the sticky outer surface. The sporocarps by repeated moistening and drying can be made to open and close many times, even after killing the living parts by heat or other means.

[1] Miyoshi, M. Untersuchungen über die Schrumpfkrankheit ("Ishikubyo") des Maulbeerbaumes. II. Bericht. *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1901), pp. 459–464.

[2] Miyoshi, M. Ueber die Sporocarpenevacuation und darauf erfolgendes Sporenausstreuen bei einer Flechte, *Journ. Coll. of Sci., Imp. Univ. Tokyo*, vol. xv, pt. iii (1901), pp. 367–370. 1 pl.

Dr. Robinson's admirable presidential address before the Botanical Society of America, on "Problems and Possibilities of Systematic Botany," is printed in *Science* of September 27.

In the *Annals of Botany* for September, A. H. Church suggests that the substitution of a logarithmic spiral in place of the Archimedian spiral for the genetic and secondary spirals in phyllotactic studies refers this complex subject to a simple relation to the distribution of energy in the growing points.

Two additional works by Rafinesque — a *Florula Lexingtoniensis* and *The American Florist* — have been unearthed by W. J. Fox in the library of the Academy of Natural Sciences of Philadelphia, as appears from a note by him in *Science* of September 27.

An interesting addition to the literature of myrmecophilous plants is a paper presented at the meeting of the British Association last summer by Yapp. The ant galleries of two Malayan species of Polypodium are described. An abstract of the paper appears in *Nature* for October 17.

Papers on the fruit and seed structure (by Lonay) and leaf anatomy (by Goffart) of Ranunculaceæ are contained in the *Mémoires de la Société Royale des Sciences de Liège*, Vol. III, issued in July.

From a study of the anatomy and embryogeny of Nelumbo, H. L. Lyon concludes, in the current volume of *Minnesota Botanical Studies*, that the Nymphæaceæ should be transferred to the monocotyledonous group Helobiæ.

Robinia neomexicana is figured in the *Tidskrift* of the Svenska Trädgaardsföreningen for July–August.

Numerous popular varieties of *Begonia semperflorens* are figured from photographs in *Die Gartenwelt* of September 28.

Several Canadian gentians of the section Crossopetalæ are reviewed by Holm in the *Ottawa Naturalist* for November.

In Part II of Vol. VII of the *Contributions from the United States National Herbarium*, Mr. O. F. Cook adduces reasons for believing in the American origin of *Cocos nucifera*.

Scirpus supinus and its North American allies are reviewed by Fernald in *Rhodora* for October.

Mr. Eaton's ninth paper on Equisetum, in the *Fern Bulletin* for October, deals with *E. litorale*.

George H. Curtis has several lists of Kansas diatoms in the *Transactions of the Kansas Academy of Science* for 1899–1900.

The flora of the Azores receives an important addition through the publication in *Nyt Magazin for Naturvidenskaberne* of a paper on the fresh-water diatoms of the archipelago, by Holmboe. The species are European rather than American, and are believed to have been introduced by adhering to migratory birds.

Professor Hitchcock publishes a list of additions to his "List of Plants in my Florida Herbarium" in Vol. XVII of the *Transactions of the Kansas Academy of Science.*

Native Kansas plants adapted to cultivation are discussed by Grace R. Meeker in Vol. XVII of the *Transactions of the Kansas Academy of Science.*

The *Journal of Applied Microscopy* for October contains an illustrated article on the botanical laboratory and garden of the Imperial University at Tokyo, by Miyake.

An excellent portrait of the late Professor Cornu accompanies the September number of the *Bulletin de la Société Botanique de France.*

The *Fern Bulletin* for October contains a portrait of Thomas Meehan.

Trabut begins an illustrated article on caprification as practiced in Algeria, in the *Revue Horticole* of November 9.

A *Flora of the Presidency of Bombay*, by Theodore Cooke, is in course of publication by Taylor & Francis of London. The familiar sequence of orders of Bentham and Hooker is followed, and the single part thus far issued reaches into Rutaceæ.

An extensive report on a botanical survey of the Dismal Swamp region, by Thomas H. Kearney, forms the concluding number of Vol. V of the *Contributions from the United States National Herbarium*, issued under date of November 6.

The plants of western Lake Erie are considered as to their ecological anatomy and distribution by A. J. Pieters in a paper separately printed from the *Bulletin of the United States Fish Commission* for 1901.

Vol. III of Professor Greene's *Plantæ Bakerianæ* begins with a fascicle of thirty-six pages devoted almost exclusively to the description of new species from Mr. Baker's collections of 1901, on the Gunnison watershed of Colorado.

Four miscellaneous phanerogamous species from Colorado are described by Osterhout in the *Bulletin of the Torrey Botanical Club* for November.

Notes on the vegetation of the Cape Nome region, Alaska, by Collier, are included in the account of the Brooks reconnaissance of Seward Peninsula, recently published by the United States Geological Survey.

A monograph of the genus Sorbus, by Hedlund, constitutes No. 1 of Vol. XXXV of the *Kongliga Svenska Vetenskaps-Akademiens Handlingar.*

The volume of *Botaniska Notiser* for 1901 contains (pp. 33–72, 83–106, 155–158) a discussion by Hedlund of the forms of *Ribes rubrum* in the broad sense.

Under the name of *Pilea heptaphyllus*, Dr. Ramírez describes and figures a representative of the Papayaceæ, in No. 1 of the current volume of *Anales del Instituto Médico Nacional*, of the city of Mexico.

An article on the preparatory fermentation of cacao, by Preyer, published in the *Tropenpflanzer* for April, is reprinted in translation in No. 10 of the *Boletin del Instituto Fisico-Geografico de Costa Rica.*

Various diseases of cacao and sugar cane and bud variation of the latter are discussed in No. 3 of the current volume of the *West Indian Bulletin*, of Barbados.

The chayote, *Sechium edule*, and its varieties are the subject of *Bulletin No. 28* of the Division of Botany of the United States Department of Agriculture, by Mr. Cook, special agent for tropical agriculture.

"Plant Breeding," an illustrated essay by Professor Hays of Minnesota, is published as *Bulletin No. 29* of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture.

Economic studies of *Rhizophora mangle*, *Avicennia nitida*, and *Eriodendron occidentalis* are published in No. 2 of the current volume of *Anales del Instituto Médico Nacional*, of Mexico, which also contains an article, by Martínez del Campo, on plants used in that country as diuretics.

A botanico-economic pamphlet on the Heveas, and the manufacture of rubber from them in Brazil, is issued as a public document by

Sr. J. Barbosa Rodrigues, director of the botanic garden of Rio de Janeiro, under the title *As Heveas ou Seringueiras*.

In No. 1197, "Advance Sheets," of *Consular Reports* is reprinted from the *Venezuelan Herald* an article by Dr. L. Morisse on rubber culture and manufacture in Venezuela from species of Hevea.

Dr. Peckolt is publishing a series of articles on the medicinal plants of Brazil in the *Berichte* of the German Pharmaceutical Society, and an alphabetic list of Portuguese and Tupi names for the economic plants of the same country in the *Pharmaceutical Archives*.

Stem and bark anatomical studies of Hamamelis (by Jensen) and Myrica (by Krembs) are published in the *Pharmaceutical Archives* for July.

From No. 3 of the *Bulletin du Jardin Impérial Botanique de St.-Pétersbourg* it appears that 33,697 species and varieties of plants were cultivated in that establishment last year. Some of the principal groups grown under glass are represented as follows: ferns, 798; orchids, 1433; cacti, 748; palms, 402; cycads, 60; conifers, 567; heaths, 186; aroids, 585; bromeliads, 420; succulents, chiefly agaves and aloes, 991. The plants grown in the open air comprise: trees and shrubs, 1240 species and varieties; perennials, 4385; and annuals, 1410. Over 37,000 persons visited the plant houses during the year.

It may not be generally known that an account of the government gardening in the District of Columbia is each year included in the *Report of the Chief of Engineers*. The volume for 1900 contains a list of the woody plants cultivated about the White House.

Sr. Rodrigues, director of the botanic garden of Rio de Janeiro, has begun the publication of a series of French *Contributions du Jardin Botanique de Rio de Janeiro* in quarto pamphlet form.

The tendency of some German investigators to confine their examination of the literature of subjects they investigate to publications by their fellow-countrymen is not inopportunely, if somewhat caustically, commented upon by Dr. MacDougal in *Torreya* for November.

An excellent portrait of the late Thomas Meehan is published in *Meehans' Monthly* for December, and a biographic sketch in the January number.

Vol. XXVI of the botanical *Bihang till Kongliga Svenska Vetenskaps-Akademiens Handlingar*, forming a thick volume, contains a wide

range of subjects, handled in the characteristically excellent Scandinavian fashion.

The *Ohio Naturalist* for November contains the following botanical articles: Tyler, "Geophilous Plants of Ohio," II; Kellerman, "Ohio Fungi Exsiccatæ," with reprint of original descriptions; Schaffner, "The Maximum Height of Plants," III.

Notes on the geotropism of fungus stipes, extrusion of the gametes of Fucus, and adaptation of *Spartina polystachya* to environment are published by E. B. Copeland in *Torreya* for November, in an account of the last season's work at the Cold Spring Harbor laboratory.

In Part II of the current volume of *Proceedings of the Academy of Natural Sciences of Philadelphia*, Dr. Harshberger discusses the limits of variation in plants, and Mr. Meehan contributes some observations on the upbending of mature wood in trees.

The anatomy of the conducting tissue of style and stigma is being considered by Guéguen in current numbers of the *Journal de Botanique.*

Eleanor E. Davie has compiled from the writings of the late W. H. Gibson an attractive little book on *Blossom Hosts and Insect Guests*, which, fully illustrated by the author's admirable drawings, is published by Newson & Co. of New York.

QUARTERLY RECORD OF GIFTS, APPOINTMENTS, RETIREMENTS, AND DEATHS.

EDUCATIONAL GIFTS.

Akron (Ohio) Public Library, $70,000, conditional from Andrew Carnegie.

Alfred University, $1000, by the will of E. P. Barker.

Amherst College, $1000, by the will of E. P. Barker.

Barnard College, Columbia University, a conditional gift of $200,000, from John D. Rockefeller.

Berea (Kentucky) College, $25,000, by the will of Mrs. George L. Stearns.

Butler (Indiana) College, $20,000 from Mr. and Mrs. E. C. Thompson of Indianapolis.

Bryn Mawr College, a conditional gift of $230,000, from J. D. Rockefeller.

Carnegie Institution, of Washington, D.C., $10,000,000 from Andrew Carnegie.

Carnegie Polytechnic Institute, of Pittsburg, $1,000,000, from Andrew Carnegie.

Chicago University, $1,250,000, from John D. Rockefeller.

Columbia University, $12,000, from Dean Lung, for the Chinese department.

Drury (Missouri) College, $8000, from E. A. Goodnow of Worcester, Mass.

Harvard University, nearly $100,000, from an anonymous donor, for a new building; $5000 for the Peabody Museum of Archæology, by the will of Mrs. S. D. Warren; $50,000, from Mr. T. Jefferson Coolidge, for physical research.

Kenyon College, $150,000, from various donors.

Manchester (New Hampshire) Institute of Arts and Sciences, $80,000, by the will of Mrs. Charles E. Balch of that city.

Metropolitan Museum of Art in New York, over $5,000,000, by the will of Jacob S. Rogers.

Montana Biological Station, $250, from Senator W. A. Clark.

Nashville, Tennessee, $100,000, from Andrew Carnegie, for a public library.

New York Botanical Garden, $3000, from Misses Oliva and Caroline Phelps Stokes.

New York Historical Society, $130,000, by the will of Miss C. B. De Peyster.

New York University, $20,200, from various persons, for a fellowship; $5000, from Miss Helen M. Gould, for a museum of pedagogy.

Northwestern University, $15,000, from an anonymous donor.

Oberlin College, $300,000, from various sources, thus securing the conditional gift of $200,000 from J. D. Rockefeller.

Palmer (Iowa) College, $30,000, from Mr. F. A. Palmer; $20,000, from other sources.

Princeton University, $2500 a year, for five years, from George A. Armour, for the classical seminary; $15,000, from the estate of John Sayre.

San Juan, Puerto Rico, $100,000, from Andrew Carnegie, for a public library.

Sheffield Scientific School of Yale University, $6000, from Edward B. Page, to found scholarships.

Springfield (Missouri) Public Library, $50,000, from Andrew Carnegie.

Syracuse University, $4000, from Mr. George C. French.

Tufts College, $50,000, and land valued at $40,000, by the will of Mrs. George L. Stearns.

Tuskegee Institute, $25,000, by the will of Mrs. George L. Stearns.

Union Christian (Indiana) College, $30,000, from Mr. A. B. Palmer of New York.

University of Pennsylvania, $25,000, from Messrs. Keasbey and Matteson; $5000, from John F. Wentz; $10,000, from the Frazer family; $20,000, from Dr. George Woodward, for a fellowship in physiological chemistry.

Vassar College, $30,000, from Miss Helen M. Gould, for scholarships; $110,000, from J. D. Rockefeller, for a new dormitory; $2000, from other sources.

Washington University, $100,000, from Mrs. James Finney How.

Wesleyan University, $125,000, from various donors for buildings.

Williams College, $5000, by the will of Mrs. S. D. Warren.

Worcester Polytechnic Institute, $30,000, from four trustees: S. Salisbury, C. H. Whitcomb, C. H. Morgan, and C. G. Washburn.

Yale University, $2500, from Mr. B. F. Barge.

APPOINTMENTS.

Wilhelm Arnell, lector in natural history in the University at Upsala. — Archibald A. Atkinson, assistant instructor in biology in the University of Oregon. — Dr. Georg Bitter, docent for botany in the Academy at Münster. — Prof. M. Büsgen, professor of botany in the school of forestry at Hannover-Münden. — Dr. Carl Busz, professor of mineralogy in the Academy at Münster. — Dr. M. Caullery, professor of zoölogy at Aix-Marseilles. — H. S. Davis, instructor in vertebrate zoölogy in the Washington Agricultural Experiment Station. — Frank S. Earle, assistant curator of the collection of fungi of the New York Botanical Garden. — Dr. Géza Entz, professor of zoölogy in the University at Budapest. — Dr. J. M. Flint, professor of anatomy in the University of California. — Willy Foy, director of the new ethnographical museum in Cologne. — Dr. Elisha H. Gregory, Jr.,

demonstrator of anatomy in the University of Pennsylvania. — W. Hammer, assistant in the Austrian Geological Survey. — Dr. Charles M. Hazen, professor of biology in Richmond (Virginia) College. — Mr. J. M. Hillier, keeper of the Museum of Economic Botany at Kew. — Mr. H. T. A. Hus, assistant in botany in the University of Amsterdam. — Henry M. Huxley, Hemenway fellow and assistant in anthropology in Harvard University. — J. T. Jenkins, lecturer on biology and geology in Hartley College, Southampton, England. — Dr. H. Joseph, docent for zoölogy and comparative anatomy in the University at Vienna. — S. Killermann, professor extraordinary of anthropology, zoölogy, and botany in the episcopal school at Ratisbon. — Dr. E. H. Kraus, instructor in mineralogy in Syracuse University. — Gustav Krause, district geologist of the Prussian Geological Survey. — Dr. A. A. Lawson, assistant in botany in Leland Stanford Junior University. — Dr. A. B. Macallum, professor of physiology in the University of Toronto. — Dr. A. Pelikan, professor of mineralogy and petrography in the German University at Prag. — Dr. R. G. Perkins, lecturer on bacteriology in the medical school of Western Reserve University. — J. M. Prather, instructor in biology in the University of Cincinnati. — Dr. K. Theodor Preuss, director's assistant in the royal museum at Berlin. — William Riley, instructor in entomology in Cornell University. — Dr. V. Schiffner, professor extraordinary of botany in the University at Munich. — Dr. Conrad von Seelhorst, professor of botany in the University at Göttingen. — Dr. Hans Solederer, professor of botany in the University at Erlangen. — Dr. Julius Stoklasa, professor of plant production in the Bohemian technical school at Prag. — Dr. E. Stolley, professor of geology in the Braunschweig Technical School. — Dr. Richard P. Strong, director of the government biological laboratory in Manila. — Dr. Roland Thaxter, professor of cryptogamic botany in Harvard University. — Dr. Victor Uhlig, professor of geology in the University at Vienna. — Dr. F. C. Waite, assistant professor of histology and embryology in the medical school of Western Reserve University. — Dr. Thomas L. Walker, professor of mineralogy and petrography in the University of Toronto. — William Watson, curator of the Kew Gardens. — H. N. Whitford, assistant in botany in the University of Chicago. — H. Winckler, first assistant in the Botanical Garden at Breslau. — Dr. Hans Winkler, docent for botany in the University at Tübingen. — Dr. A. Smith Woodward, keeper of geology in the British Museum. — Oscar Zeise, land geologist of the Prussian Geological Survey.

RETIREMENTS.

J. R. Jackson, from the keepership of the Museum of Economic Botany at Kew, after forty-three years of service. — George Nicholson, from the curatorship of the Kew Gardens, after twenty-eight years of service. — Dr. M. Ussow, from the directorship of the Zoötomical Institute of the University at Kasan. — Dr. Arthur Willey, from his position as director of

the Museum at Demerara, British Guiana. — Dr. Henry Woodward, from his position as keeper of geology in the British Museum. — Dr. John Young, from the chair of natural history in Glasgow, after thirty-five years of service.

DEATHS.

Lugui Maria D'Albertis, the ornithologist and explorer, in Sassari, early in September. — Dr. F. Arnold, lichenologist, in Munich, August 8, aged 73. — F. J. Birtwell, ornithologist, by an accident, in New Mexico, June 28. — David Carnegie, botanist and explorer, on the Middle Niger, Nov. 27, 1900, aged 30. — Albert Nelson Cheney, ichthyologist, at Glens Falls, N.Y., August 18. — Dr. J. H. Chievetz, director of the Anatomical Museum at Copenhagen. — Professor Miguel Colmeiro, director of the botanical gardens at Madrid, aged 86. — Dr. Carl Cramer, professor of botany in the Polytechnicum at Zürich. — William Doherty, entomological and ornithological collector in Nairoba, East Africa, May 25. — Dr. James Foulis, anatomist, in Edinburgh, October 17. — Prof. Dr. Robert Hartig of Munich forestry station, October 10, aged 62. — Prof. Alfonso Herrera, in Mexico, Jan. 27, 1901, aged 67. — Dr. Federico Horstman y Cantos, professor of anatomy in the University of Havana. — Dr. Georg Jablonowski, assistant in the Anatomical Institute in Berlin, September 28. — Josef Bernhard Juch, cryptogamic botanist, in Constance, August 14, aged 83. — Clarence King, director of the United States Geological Survey, 1878–1881, December 24, at Phœnix, Arizona. — James Walker Kirkby, geologist and student of fossil ostracodes, in Levin, Scotland, July 30, aged 66. — Dr. Arthur König, professor extraordinary of physiology in the University at Berlin, October 26, aged 45. — Prof. A. A. Kowalevski, formerly professor of zoölogy in the University at St. Petersburg, November 22. — Dr. Albrecht von Krafft of the Indian Geological Survey in Allahabad, in September. — Jacob Heinrich Krelage, a Dutch botanist, December 1, aged 76. — Henri Lacaze-Duthiers, the eminent French zoölogist, July 21. — L. Liener, botanist in Constance, in May. — Rev. Hugh Alexander Macpherson, a Scotch zoölogist, aged 43. — Prof. M. Märcher, director of the Agricultural Experiment Station at Halle, Oct. 19, 1901. — Mr. Thomas Meehan, the well-known botanist, at Germantown, Pa., November 29, aged 75. — Charles F. Mohr, botanist in Asheville, N.C., July 17. — Dr. H. Müggenburg, dipterologist in the Zoölogical Museum in Berlin, July 3. — Count Emil Neuhauss, student of Lepidoptera, April 21, aged 57. — Henri Philibert, professor of botany in Aix, May 14, aged 79. — Dr. Max Reess, formerly professor of botany in the University at Erlangen, in Klingenmünster, September 14, aged 56. — Louis Schneider, botanist and entomologist, in Philadelphia, aged 65. — Dr. L. Serrurier, formerly director of the ethnological museum in Leiden, in Batavia, July 7. — George B. Simpson, student of fossil Polyzoa and a well-known paleontological artist, at Albany, N.Y., October 15. — Dr. Henry Spencer

Smith, of London, October 29, aged 88. — Hermann Strecker, entomologist, at Reading, Pa., November 30, aged 65. — Dr. Peter Cormack Sutherland, formerly government geologist of Natal, in Durban, Nov. 30, 1900, aged 79. — Ralph Tate, professor of natural history in the University at Adelaide, Australia. — Dr. Wilhelm Tomaschek, professor of geography in the University at Vienna, September 9, aged 60. — Dr. A. A. Tokasy, head of the physiological laboratory at Moscow. — William West, student of fresh-water algæ, in India, of cholera, aged 26. — Lionel L. Wigglesworth, ornithologist, in Viti Levu, June 7, aged 37.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

Bartholomew, E. Ellis and Everhart's "Fungi Columbiani": Alphabetical Index, Centuries I–XV. — Beecher, C. E. Studies in Evolution. New York, Charles Scribner's Sons, 1901. xxiii + 638 pp., 34 pls. — Church, A. H. On the Relation of Phyllotaxis to Mechanical Laws. Pt. i, Construction by Orthogonal Trajectories. Oxford, Williams & Norgate. 8vo, 78 pp., 10 pls., 34 text-figs. — Cole, G. W. Bermuda and the Challenger Expedition. Printed for private distribution. Boston, 1901. 16 pp. — Comstock, J. H., and Kellogg, V. L. The Elements of Insect Anatomy: an Outline for the Use of Students in Entomological Laboratories. Third edition, revised. Comstock Publishing Co., Ithaca, N.Y., 1901. 145 pp., 11 figs. — Getsinger, E. C. A New Theory of Biology. Reprinted from the *Medical Times*, November, 1901. 17 pp. — Government Museum and Connemara Public Library: *Report on the Administration for the Year 1900–1901*. — Morgan, T. H. Regeneration. Columbia University Biological Series, No. 7. New York, The Macmillan Company, 1901. xii + 316 pp., 66 figs. $3.00. — United States Geological Survey. *Twenty-first Annual Report*, 1899–1900. Pt. i, xi + 608 pp.; pt. vi, 656 pp.; pt. vi (*continued*), xi + 634 pp.

Allen, J. A. The Proper Generic Names of the Viscacha, Chinchillas, and their Allies. *Proc. Biol. Soc., Washington*. Vol. xiv, pp. 181–182. — Allen, J. A. Note on the Names of a Few South American Mammals. *Proc. Biol. Soc., Washington*. Vol. xiv, pp. 183–185. — Baker, F. C. Some Interesting Molluscan Monstrosities. *Trans. Acad. Sci., St. Louis*. Vol. xi, No. 8, pp. 143–146, Pl. XI. 1901. — Banks, N. Papers from the Hopkins Stanford Galapagos Expedition, 1898–1899. V. Entomological Results (5). Thysanura and Termitidæ. *Proc. Wash. Acad. Sci.* Vol. iii, pp. 541–546. — Blasdale, W. C. Contributions to the Mineralogy of California. *Bull. Dept. Geol., Univ. of Cal.* Vol. ii, pp. 327–348. — Buckley, E. R. The Clays and Clay Industries of Wisconsin. *Bull. Wis. Geol. and Nat. Hist. Surv.*, No. 7, pt. i. Economic Series No. 4. — Chapman, F. M. The Bird Rock Group. Supplement to *American Museum Journal*. Vol. i, No. 11, October, 1901. 24 pp., numerous figs. — Coe, W. R. The Nemerteans of Porto Rico. *Bull. U. S. Fish. Com. for 1900*. Vol. ii, pp. 223–229. — Coville, F. V. Papers from the Harriman Alaska Expedition, XXVI. Harrimanella, a New Genus of Heathers. *Proc. Wash. Acad. Sci.* Vol. iii, pp. 569–576, text-figs. 62–66. — Dall, W. H., and Simpson, C. T. The Mollusca of Porto Rico. *Bull. U. S. Fish Com. for 1900*. Vol. i, pp. 351–524, Pls. LIII–LVIII. — Eakle, A. S. Mineralogical Notes. *Bull. Dept. Geol., Univ. of Cal.* Vol. ii, pp. 315–326, Pl. IX. — Eigenmann, C. H. Description of a New Oceanic Fish found off Southern New England. *Contributions from the Biological Laboratory, U. S. Fish Com., Woods Hole, Mass.* — Eigenmann, C. H. Investigations into the History of the Young Squeteague. *Bull. U. S. Fish Com. for 1901*. Pp. 45–51. — Elrod, M. J. Limnological Investigations at Flathead

Lake, Montana, and Vicinity, July, 1899. *Trans. Amer. Micr. Soc.* Vol. xxii, pp. 63–80, Pls. X–XVII. May, 1901. — FELT, E. P. Scale Insects of Importance and List of the Species in New York State. *Bull. New York State Museum,* No. 46. Pp. 291–377. 15 pls. — GRANT, U. S. Preliminary Report on the Copper-Bearing Rocks of Douglas County, Wisconsin. *Bull. Wis. Geol. and Nat. Hist. Surv.,* No. 6 (second edition). Economic Series No. 3. — HARGITT, C. W., and REGERS, C. G. The Alcyonaria of Porto Rico. *Bull. U. S. Fish Com. for 1900.* Vol. ii, pp. 265–287, Pls. I–IV. — HUNTER, S. J. On the Production of Artificial Parthenogenesis in Arbacia by the Use of Sea Water concentrated by Evaporation. *Amer. Journ. of Phys.* Vol. vi, pp. 177–180. November, 1901. — IKEDA, I. Observations on the Development, Structure, and Metamorphosis of Actinotrocha. *Journ. Coll. Sci., Imp. Univ. Tokyo.* Vol. xiii, pp. 507–592, Pls. XXV–XXX. 1901. — JENKINS, O. P. Descriptions of Fifteen New Species of Fishes from the Hawaiian Islands. *Bull. U. S. Fish Com. for 1899.* Pp. 387–404. 1901. — JORDAN, D. S., and SNYDER, D. O. A Review of the Gymnodont Fishes of Japan. *Proc. U. S. Nat. Mus.* Vol. xxiv, pp. 229–264. — LINTON, E. Parasites of Fishes of the Woods Hole Region. *Bull. U. S. Fish Com. for 1899.* Pp. 405–492, Pls. I–XXXIV. 1901. — MERRIAM, C. H. Description of Twenty-three New Harvest Mice (Genus Reithrodontomys). *Proc. Wash. Acad. Sci.* Vol. iii, pp. 547–558. 1901. — MERRIAM, C. H. Seven New Mammals from Mexico, including a New Genus of Rodents. *Proc. Wash. Acad. Sci.* Vol. iii, pp. 559–563. 1901. — MERRIAM, C. H. Preliminary Revision of the Pumas (*Felis concolor* group). *Proc. Wash. Acad. Sci.* Vol. iii, pp. 577–600. — MOHR, C. Notes on the Red Cedar. *Bull. U. S. Dept. Agr., Dept. of Forestry,* No. 31. 37 pp., 13 text-figs., 3 pls. — NEEDHAM, J. G., and BETTEN, C. Aquatic Insects in the Adirondacks. *Bull. New York State Museum,* No. 47. 1901. Pp. 383–612. 36 pls. — OBERHOLSER, H. C. Seven New Birds from Paraguay. *Proc. Biol. Soc., Washington.* Vol. xiv, pp. 187–188. — OSGOOD, W. H. A New White-Footed Mouse from California. *Proc. Biol. Soc., Washington.* Vol. xiv, pp. 193–194. — PIETERS, A. J. The Plants of Western Lake Erie, with Observations on their Distribution. *Bull. U. S. Fish Com. for 1901.* Pp. 57–79, Pls. XI–XX. — PRICE, O. W. Practical Forestry in the Southern Appalachians. Reprint from the *Yearbook U. S. Dept. of Agr. for 1900.* Pp. 357–368. 6 pls. — RICHARDSON, H. Papers from the Hopkins Stanford Galapagos Expedition, 1898–1899. VI. The Isopods. *Proc. Wash. Acad. Sci.* Vol. iii, pp. 565–568. 1901. — RIDGWAY, R. The Birds of North and Middle America. Pt. i, Tringillidæ. *Bull. U. S. Nat. Mus.,* No. 50. xxxi+715 pp., 20 pls. Washington, 1901. — SAUNDERS, DE ALTON. Papers from the Harriman Alaska Expedition. XXV. The Algæ. *Proc. Wash. Acad. Sci.* Vol. iii, pp. 391–486, Pls. XLIII–LXII. November, 1901. — SMITH, H. I. A New Archeological Publication. *Science,* N.S. Vol. xiii, pp. 300–301. — SMITH, H. I. A Summary of Wisconsin Archeology. *Science,* N.S. Vol. xiii, pp. 794–795. — STEJNEGER, L. Diagnoses of Eight New Batrachians and Reptiles from the Riu Kiu Archipelago, Japan. *Proc. Biol. Soc., Washington.* Vol. xiv, pp. 189–191. — THOMPSON, M. T. A New Isopod Parasitic on the Hermit Crab. *Bull. U. S. Fish Com. for 1901.* Pp. 53–56, Pls. IX–X. — TOWNSEND, C. H. Dredging and Other Records of the U. S. Fish Commission Steamer *Albatross,* with Bibliography relative to the Work of the Vessel. *U. S. Fish Com. Report for 1900.* Pp. 387–562, Pls. I–VII. — TRELEASE, W. The Progress made in Botany during the Nineteenth Century. *Trans. Acad. Sci., St. Louis.* Vol. xi, No. 7,

pp. 125–142. November, 1901.—VAUGHAN, T. W. The Stony Corals of the Porto Rican Waters. *Bull. U.S. Fish Com. for 1900.* Vol. ii, pp. 289–320, Pls. I–XXXVIII.—WALLICH, C. A Method of recording Egg Development for Use of Fish-Culturists. *U.S. Fish Com. Report for 1900.* Pp. 185–194. 1 pl.—WHEELER, H. J. Commercial Fertilizers. *Bull. Rhode Island Agr. Exp. Sta.*, No. 81. Pp. 111–112. October, 1901.—WHITE, D. Two New Species of Algæ of the Genus Buthotrephis from the Upper Silurian of Indiana. *Proc. U.S. Nat. Mus.* Vol. xxiv, pp. 265–270, Pls. XVI–XVIII.

The *American Antiquarian and Oriental Journal.* Vol. xxiii, No. 6.—The *American Journal of Science.* Ser. 4. Vol. xii, No. 72. December, 1901.—The *American Museum Journal.* Vol. i, No. 11. October, 1901.—*Anales del Museo Nacional de Montevideo.* Tome ii, pp. 417–492.—*Annales de la Société Entomologique de Belgique.* Tome xlv, pt. xi.—The *Botanical Gazette.* Vol. xxxii, No. 5. November, 1901.—*Botanisches Centralblatt.* Bd. lxxxviii, Nos. 5–10.—*Bulletin of the Johns Hopkins Hospital.* Vol. xii, No. 127. October, 1901.—*Bulletin of the Johns Hopkins Hospital.* Vol. xii, No. 128.—*Bulletin of the Torrey Botanical Club.* Vol. xxviii, No. 11. November, 1901.—The *Canadian Entomologist.* Vol. xxxiii, No. 12.—*Journal of the Cincinnati Society of Natural History.* Vol. xx, No. 1. 1901.—Linnean Society of New South Wales. Abstract of *Proceedings*, Aug. 28, Sept. 25, Oct. 30, 1901.—*Naturæ novitates*, 1901. Nos. 19–21.—The *Ohio Naturalist.* Vol. ii, No. 1.—*Proceedings of the Nebraska Ornithologists' Union at its Second Annual Meeting*, 1901. 101 pp., 10 pls.—*Proceedings of the Philadelphia Academy of Natural Sciences*, 1901. Pp. 513–544.—*The Procession*, a Magazine of Science and General Interest. Los Angeles. Vol. i, No. 1.—*Revista Chilena de Historia Natural.* Año v, Nos. 8, 9.—Rhode Island Agricultural Experiment Station. *Fourteenth Annual Report.* Pt. ii.—*Science Gossip.* Vol. viii, No. 91. December, 1901.—*Zoologischer Anzeiger.* Bd. xxiv, Nos. 655, 657–658.

Applications for the American Women's Table at the Naples Station and the Investigator's Table at Woods Hole.

The Association for Promotion of Scientific Research by Women announces that applications should be received before March 1 for the American Women's Table at the Zoölogical Station at Naples. For the summer of 1902 the Association offers the free use of an Investigator's Table at the Marine Biological Laboratory at Woods Hole, Mass., to any applicant who is eligible for the Naples Table, and who may desire the benefit of preliminary work at Woods Hole.

Application blanks for the use of candidates, items relating to the expense of living at Naples, and full information as to the advantages for research at the Station may be obtained from the Secretary,

MISS CORNELIA M. CLAPP,
Mount Holyoke College,
SOUTH HADLEY, MASS.

(No. 421 was mailed January 7.)